part of paper # 12

PATENT

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Patricia Meade

Signature

Applicant	:	Kenneth W. Baun, et al.
Application No.:	:	09/551,332
Filed	:	April 18, 2000
Title	:	FULLY AUTOMATED TELESCOPE SYSTEM WITH DISTRIBUTED INTELLIGENCE
Grp./Div.	:	2872
Examiner	:	WINSTEDT, J.
Client Matter No.	**:**	**12082-19/JWE**

DECLARATION UNDER 37 CFR 1.132

Post Office Box 7680
Newport Beach, CA 92660-6441
April 23, 2001

Assistant Commissioner for Patents
Washington, D.C. 20231

Commissioner:

I, John W. Eldredge, Applicant's attorney and of record in this application, declare as follows:

Among its other advantages, the invention encompasses automated telescope systems that allow an amateur, or someone who has absolutely no knowledge of the night sky, to orient an altitude/azimuth configured telescope system to the celestial sphere and to acquire, track and view celestial objects with the flexibility and facility approaching that of an experienced astronomer. Such embodiments of the invention can eliminate much of the tedious and complicated preparation commonly required by prior art telescope systems. For example, a user of such embodiments of the invention can be freed from the need, presented in using equatorial-type telescope systems, to adjust

6

specific ones of overhead stars and be able to orient the telescope system to those stars during the initialization process. Prior telescope systems either required a user to move the telescope to two or more alignment stars and tell the system which stars the telescope was pointing towards, or the system would command a user to point towards a specific alignment star or stars and assume the user was indeed pointing the telescope towards that designated celestial object. Any error in the process resulted in alignment or orientation failure.

In other words, some one expressing an interest in astronomy needed to acquire a certain degree of astronomical knowledge before they were even able to orient a conventional telescope system, much less use that telescope system to explore the night sky. Indeed, many persons who might have wished to use a computerized telescope to explore the sky and expand their interest in astronomy, were unable to do so because they could not perform the most basic of tasks, i.e., orienting their telescope system. These first-time experiences often resulted in disappointment for the inexperienced amateur, many of whom did not survive the experience and stay in the hobby.

The telescope system of the present invention implements a novel telescope orientation methodology that only requires a user to know the time and date, the name of their city or town (or the name of the closest city or town to their location), have a fair ideal of where "level" is, and have a fair idea of where "north" is. All of these pieces of user provided information are expressed in simple, every day terminology and are all earth-based (terrestrial-based) expressions. The telescope system of the invention takes these earth-based input data and processes them in a computationally intensive fashion, in order to derive a virtual telescope location within the visible portion of the celestial sphere. Additionally, the system maintains an awareness, not only of its virtual location, but also of the specific orientation of the telescope tube with respect to the celestial coordinate

system. Maintaining this awareness and using this information to acquire and track celestial objects is also very computationally intensive and requires use of a capable processor.

An additional aspect of a proper automated telescope system is its degree of motor control refinement, particularly with regard to a precision positioning system that physically moves the telescope system to acquire a stellar object and then track that stellar object's motion. This calculation and tracking is not limited to stars. The system can calculate and track the faster motion of planets. Even more difficult is to track the complex and much faster, earth-circling manmade satellites and space stations which have no fixed-parameter orbits. The telescope motion control system must be able to precisely acquire and track all of these types of celestial objects.

The industry has experienced a great deal of difficulty in devising an automated telescope system that is able to perform both of these tasks with equal facility. As processing power increases, more and more of it is devoted to the computationally intensive tasks of alignment, orientation and motion prediction. Computations become even more complex when the telescope is adapted to an alt-azimuth mount, since the axes cannot be driven at a constant rate when tracking. Both of the axes are subject to a dynamic equation of motion and must operate at speeds that change radically with respect to angle over short arc spans. Since more and more of the processor's capability is being used by computationally intensive tasks, the microprocessor is able to spend less and less time with motor control functions.

Accordingly, the industry has long felt a need for an automated telescope system that is simple to use, uncomplicated to setup and is able to exhibit precise position control. This long-felt need is established and particularly referred to in accompanying articles 1, 2, 3, 4, 9, and 12, specifically article 12, which discusses the lack of young people entering the hobby. Each of articles

1, 2, 3, 4 and 12 characterize this long-felt need in terms of a lack of a telescope system that is simple and easy to use, particularly with regard to orientation and alignment. Articles 3 and 12, particularly refer to the lack of an effective and affordable beginner's telescope.

The advantages of distributed intelligence illustrated by the telescope embodiment demonstrated to the Examiner allows an amateur, or someone who has no knowledge of the night sky, to acquire, track and view celestial objects with much of the same flexibility and facility as an experienced astronomer. In particular, Applicants discussed with the Examiner the advantages of the demonstrated embodiment's distribution of processing intelligence between a command processor, which carries out a number of computationally intensive tasks, and motor control processors. In the demonstrated embodiment, the command processor computes celestial object location, automatically selects orientation stars which are above the user's horizon, calculates dynamic movement profiles for axial movement of an alt-azimuth telescope system so as to track both sidereal and non-sidereal object motion, and delivers appropriate motor movement commands to the motor control processors. Those processors, in turn, perform time-intensive and sometimes continuous operations needed to operate the telescope's axial motors to position the telescope where the command processor desires. As Applicants discussed with the Examiner, this distributed intelligence architecture offers significant advantages over prior-art type telescope systems that relied on a single microprocessor controlled command unit for all of their processing, including both computationally intensive tasks and generation of all commands needed to operate the systems' motors. Reducing the demands on the command processor enhances its ability to efficiently perform complex computational tasks, while the motor control processors, which need not perform the complex tasks allocated to the command processor, are able to control motion of the telescope about their respective axes with enhanced efficiency and refinement.

Article 3 offers clear support for the claimed invention's advantages in addressing the industry's long-felt need when stating "[T]he synergy you can achieve between a smart controller and a precision positioning system yields a new way of solving a long-standing setup problem." Additionally, articles 8, 10 and 12 discuss the "revolutionary" nature of the smart controller (Autostar) used in conjunction with a motorized system, which allows realization of features previously unobtainable in even the most expensive of systems.

Distributing the functional intelligence between command processing and motor control processing results in a command processor that is free to perform the complex calculations necessary to implement a simple and effective alignment procedure. In particular, almost all of the accompanying articles characterize the novel telescope system in terms of its ability to make a telescope simple, and easy to use by a rank amateur, by performing a large number of high-level complex calculations in order to make determinations that were previously forced upon a user. In particular, the accompanying literature lauds the novel system for its "revolutionary" "point north and level" orientation system which is carried out by the system's command processor, which need not concern itself with ancillary time and weight/interrupt states taken up by motor control calculations.

Additionally, Applicants' invention has been a notable commercial success. Indeed, since the introduction of products embodying Applicants' invention, the industry has witnessed the creation of a new market segment directed to such products. Competitors have quickly copied Applicants' invention, taking advantage of Applicants' inventive efforts, and exploiting the new market segment which was created as a result of those efforts.

As noted in Article 2, about 50 of 150 attendees of a telescope user's course owned a telescope of the type embodying the invention in about January of 2001, while the preceding years' course admitted only a single one. A remarkable increase, in only a single year, and brought about by the availability of telescope systems of the type embodying the invention.

Articles 3 and 4 note that Applicant's assignee introduced these types of telescope systems, with competitive systems following approximately six months after. As evidenced by articles 13 – 17 inclusive, each of these competitive systems are advertised as "revolutionary" or "amazing" in character, and specifically refer to their "Auto Align" feature as facilitating alignment. Upon physical examination of samples of competitive product, it was found that all of them incorporated command processor and motor control processors configured in a distributed intelligence architecture, in accordance with the invention.

The telescope system embodying the invention as expressed in the claims, addresses a long-felt need in the field of amateur astronomy, and so successfully addresses this need that it is the subject of many awards for innovation and has been characterized as revolutionary. The objective evidence presented herewith establishes that the solution to this long-felt difficulty is directly related to the claimed invention. Consideration is respectfully solicited.

Respectfully submitted,

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Application No. 09/551,332

	Author	Title of Article	Name & Date of Publication
1.	Leif J. Robinson	Everyone's Telescope	Sky & Telescope, May 1999
2.	Alan Dyer	Five "Go To" Telescopes for Beginners	Sky & Telescope, May 1999
3.	Bill Schweber	Telescope design integrates computer control with new approach to old problems	EDN, October 12, 2000
4.	Advertisement	2000's Dueling Telescopes, Part II	Sky & Telescope, December 2000
5.	Dennis di Cicco	And the Winner Is . . .	Sky & Telescope, April 2000
6.	Gary Seronik	Meade's ETX-125EC – A First Look	Sky & Telescope, October 1999
7.	Dennis di Cicco and Gary Seronik	Go To Telescope Showdown	Sky & Telescope, February 2000
8.	Dennis di Cicco	Robotic Telescopes for the Masses	Sky & Telescope, September 1999
9.	J. Kelly Beatty	Where Are the Young Astronomers?	Sky & Telescope, September 2000
10.	Advertisement	Pointing the Way	Sky & Telescope, December 1999
11.	Advertisement	Ticket to the Stars	Popular Science, December 1999
12.	David J. Eicher	TELESCOPES FOR THE MASSES, Versatile and affordable, Meade's ETX-60AT and ETX-70AT refractors are automated guides to the night sky.	ASTRONOMY, February 2001
13.	Advertisement	Tasco StarGuide and StarGuide 60	ASTRONOMY, December 2000
14.	Advertisement	THIS IS WHAT HAPPENS WHEN YOU TELL YOUR ENGINEERS THE SKY'S THE LIMIT – CELESTRON	Sky & Telescope, March-April 2001
15.	Advertisement	The NexStar™ Just Got Brighter! Introducing the New Celestron NexStar 8.	Sky & Telescope, May, June, July, Aug., Sept., Oct., November 2000
16.	Advertisement	The Universe Is Full of Mysteries. Using NexStar™ Isn't One of Them.	Sky & Telescope, Feb., Mar., Apr., July, Aug., Sept., October 2000
17.	Advertisement	What makes the new Celestron NexStar™ 5 the most revolutionary computerized GOTO telescope on Earth?	Sky & Telescope, Oct., Nov. 1999; Jan. May, June 2000
18.	Manual	Celestron NexStar *5 Instruction Manual	Celestron International, Torrance California 90503 (Copyright 1999)

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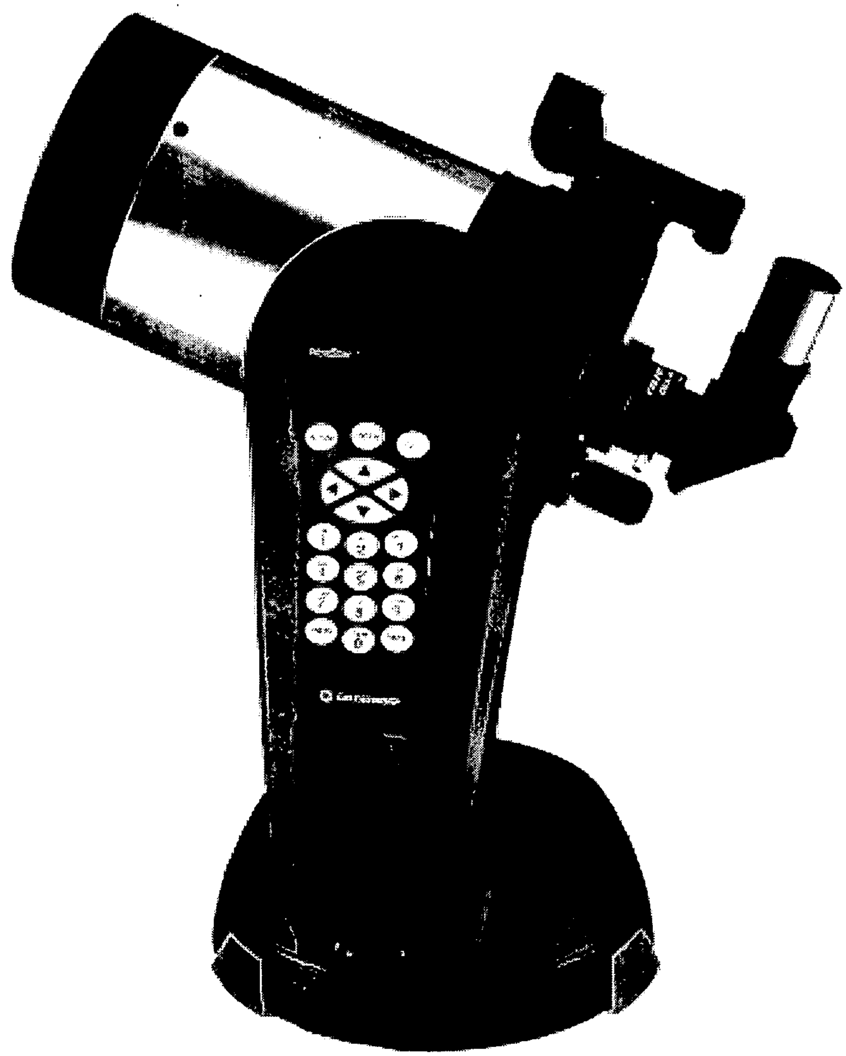
CELESTRON



NexStar™ 5

INSTRUCTION MANUAL

Introduction

Congratulations on your purchase of the Celestron NexStar! The NexStar ushers in a whole new generation of computer automated technology. Simple and friendly to use, the NexStar is up and running after locating just two alignment stars. It's the perfect combination of power and portability. If you are new to astronomy, you may wish to start off by using the NexStar's built-in SkyTour feature, which commands the NexStar to find the most interesting objects in the sky and automaticall slews to each one. Or if you are an experienced amateur, you will appreciate the comprehensive database of over 18,000 objects, including customized lists of all the best deep-sky objects, bright double stars and variable stars. No matter at what level you are starting out, the NexStar will unfold for you and your friends all the wonders of the Universe.

Some of the many standard features of the NexStar include:

- Incredible 6°/second (or faster) slew speed.
- Fully enclosed optical encoders for position location.
- Integrated hand controller – built into the side of the fork arm.
- RS-232 port allows use with a computer and software programs like *The Sky* for point and click slewing.
- Storage for programmable user defined objects; and

Many other high performance features

The NexStar's deluxe features combine with Celestron's legendary Schmidt-Cassegrain optical system to give amateur astronomers one of the most sophisticated and easy to use telescopes available on the market today.

Take time to read through this manual before embarking on your journey through the Universe. It may take a few observing sessions to become familiar with your NexStar, so you should keep this manual handy until you have full mastered your telescope's operation. The NexStar hand control has built-in instructions to guide you through all the alignment procedures needed to have the telescope up and running in minutes. Use this manual in conjunction with the on-screen instructions provided by the hand control. The manual gives detailed information regarding each step as well as needed reference material and helpful hints guaranteed to make your observing experience as simple and pleasurable as possible.

Your NexStar telescope is designed to give you years of fun and rewarding observations. However, there are a few things to consider before using your telescope that will ensure your safety and protect your equipment.

Warning

- **Never look directly at the sun with the naked eye or with a telescope (unless you have the proper solar filter). Permanent and irreversible eye damage may result.**
- Never use your telescope to project an image of the sun onto any surface. Internal heat build-up can damage the telescope and any accessories attached to it.
- Never use an eyepiece solar filter or a Herschel wedge. Internal heat build-up inside the telescope can cause these devices to crack or break, allowing unfiltered sunlight to pass through to the eye.
- Never leave the telescope unsupervised, either when children are present or adults who may not be familiar with the correct operating procedures of your telescope.

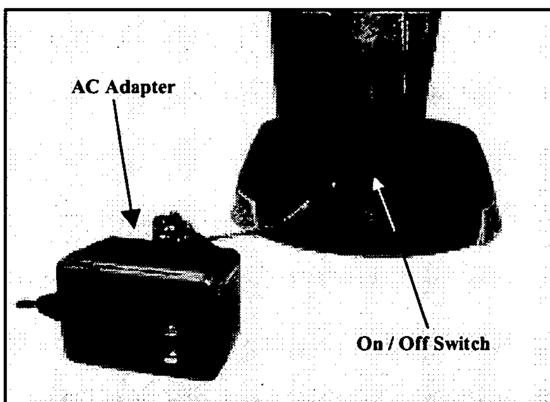
CELESTRON

Quick Setup

1

Remove the NexStar from its packaging and place the base on a sturdy, level surface. Remove the accessories from their individual boxes.

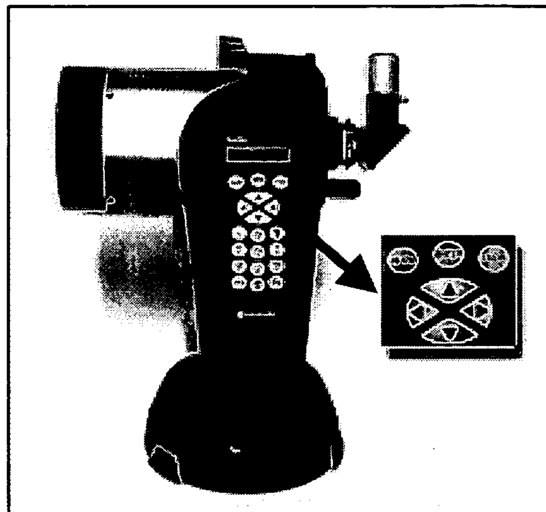
2



Plug-in the supplied 12v AC adapter* into the jac at the base of the fork arm and an AC outlet. Power the NexStar by flipping the "On/Off" switch to th "On" position.

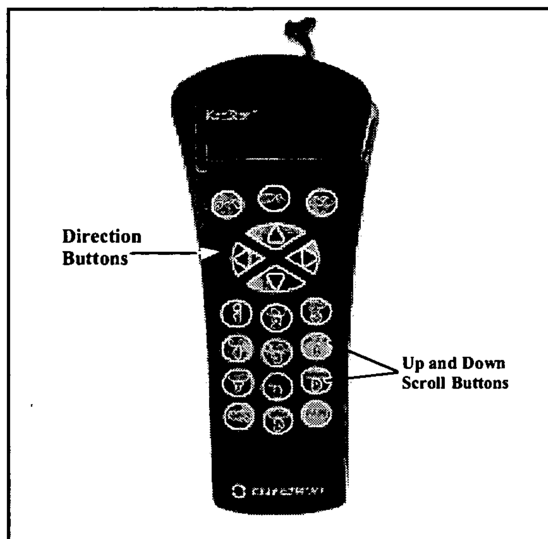
***Note: Use only the AC adapter supplied b Celestron. Using any other adapter may damage the electronics and will void your manufacturer's warranty.**

3



Press ENTER on the hand control to begin alignment. Use the Up and Down arrow buttons to position the tube horizontal to the ground. Attac the included accessories (star diagonal, eyepiece and Star Pointer finderscope) and remove the front lens cover. Turn on Star Pointer by rotating the dial on the side. (For instructions on aligning the Star Pointer see page 9).

4



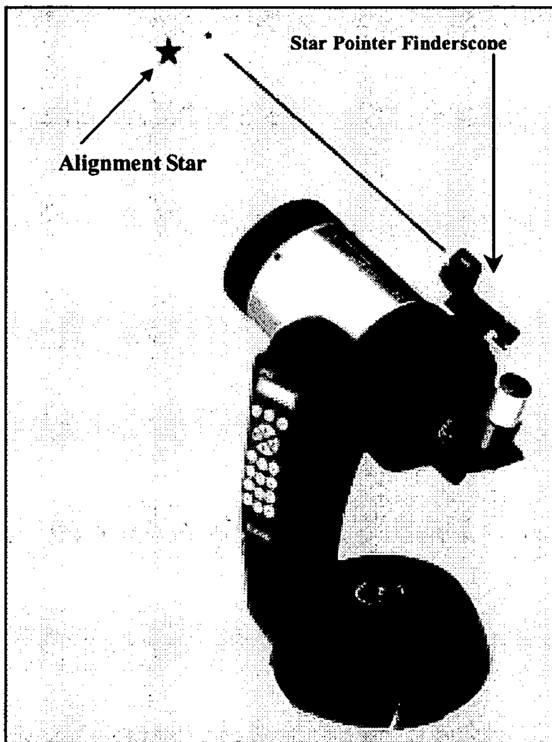
Use the Up and Down scroll buttons to get to the *AutoAlign* menu. Press ENTER. Use the direction arrow keys to level the tube and rotate it towards North. (See *Astronomy Basics* for help on finding North). Input the necessary date and time information as instructed by the hand control. (See *Hand Control* section for complete instruction on entering data).

5

APPENDIX C	LONGITUDE degrees	min	LATITUDE degrees	min
Torrance	118	19.8	33	48
Travis AFB	121	55.8	38	16.2
Tahoe	120	7.8	39	19.2

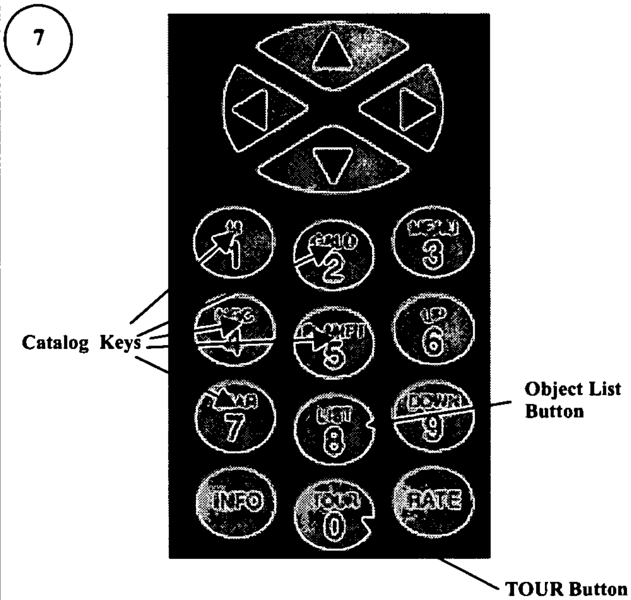
The first time the NexStar is used, the longitude and latitude must be entered into the hand control. When the display reads, *Select Location,* use Appendix C to look up the longitude an latitude of your nearest city and enter it into the hand control. When asked to *Save Location,* press ENTER and assign the number 1 to the current location. This number can be used for future alignments. (See page 13 for complete alignment procedures.)

6



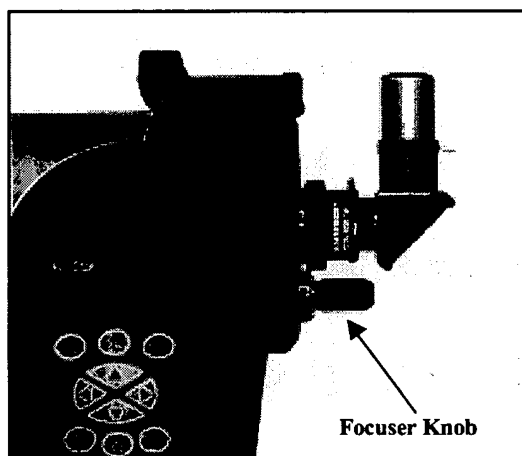
The NexStar will automatically pick an alignment star and slew the telescope close to that star. Once there, the display will as you to use the arrow buttons to aim the Star Pointer at the star. If the star is not visible (perhaps behind a tree), press UNDO to select a new star. Next, center the star in the eyepiece and press ALIGN. Repeat these steps for the second star alignment. When complete, display will read "`Alignment Successful`".

7



Press the TOUR button on the hand control. Use the Up and Down scroll keys to select the current month and press ENTER. The hand control will display the first object that is visible for that month. Press INFO to read information about the object displayed. Press the DOWN scroll key to display the next object. Press ENTER to slew to (go to) the displayed object.

8



Use the focus knob to bring objects into a sharp focus. Use arrow keys to center objects in the eyepiece. (See page 27 for observing hints and techniques).

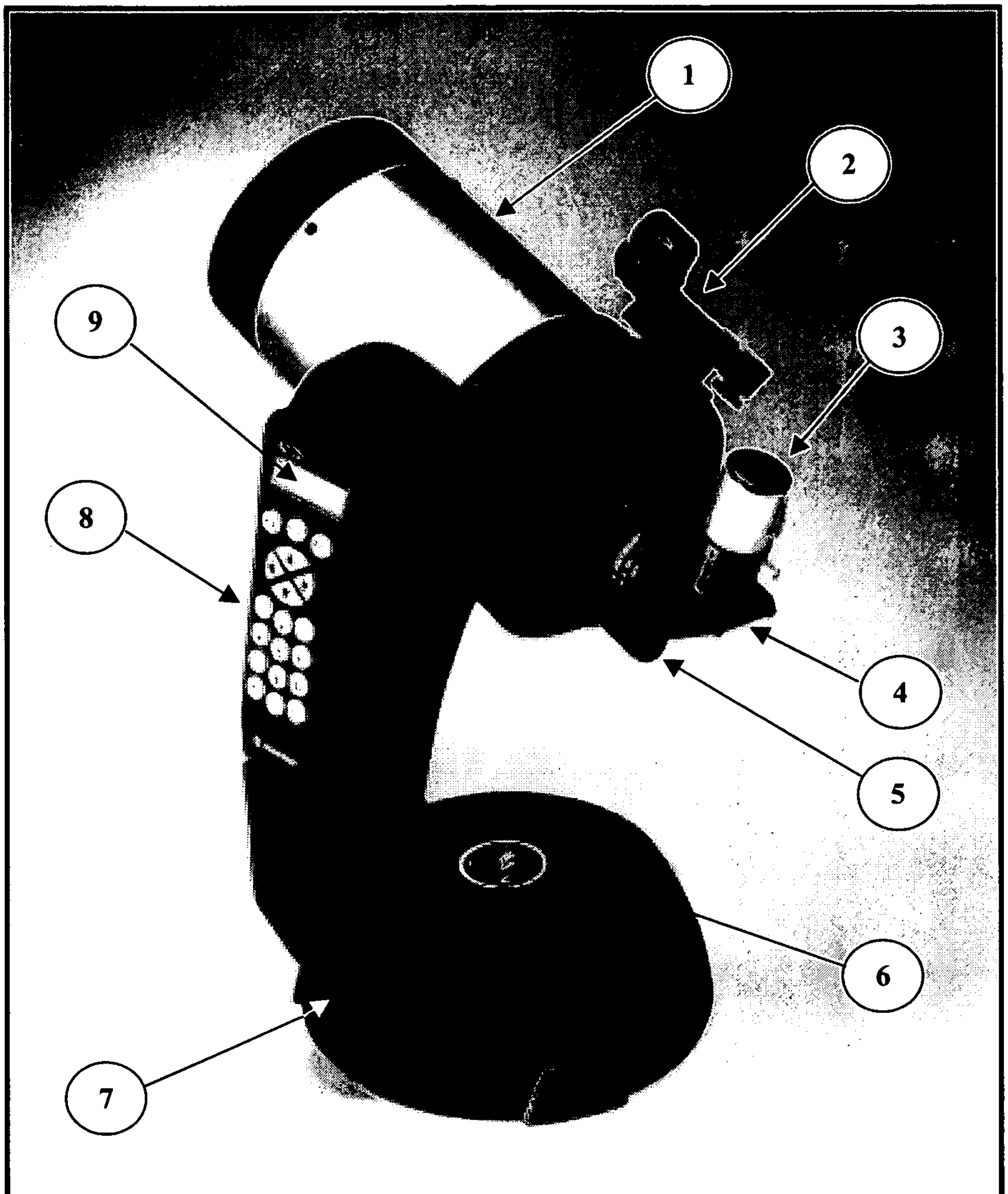


Figure 1-A - The NexStar

1	Optical Tube	5	Focuser Knob
2	Star Pointer Finderscope	6	Battery Compartment
3	Eyepiece	7	ON/OFF Switch
4	Star Diagonal	8	Hand Control
		9	Liquid Crystal Display

Assembly

The NexStar comes completely pre-assembled and can be operational in a matter of minutes. The NexStar is convenientl packaged in one reusable shipping carton that contains all of the following accessories

- 25mm Plossl Eyepiece – 1¼"
- 1¼" Star Diagonal
- Star Pointer Finderscope and Mounting Bracket
- 1¼" Visual Back (attached to the optical tube)
- AC adapter

Assembling the NexStar

Start by removing the telescope from its shipping carton and setting the round base on a flat table or surface. It is best to carry the telescope by holding it from the lower portion of the fork arm and from the bottom of the base. **Do not try to move the optical tube at this time. It should remain facing down until the telescope is powered up**. Remove all of the accessories from their individual boxes. Remember to save all of the containers so that they can be used to transport the telescope. Before attaching the visual accessories, the telescope tube should be positioned horizontal to the ground. To do this, the telescope needs to be powered up and the optical tube must be moved remotely with the hand control.

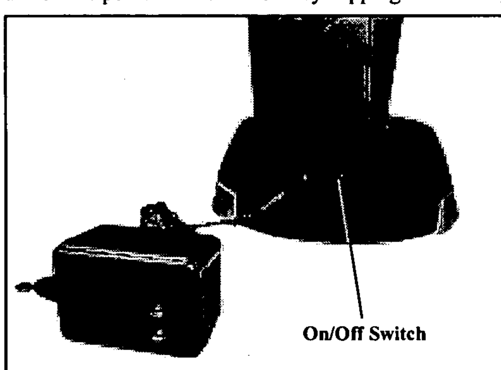
Powering the NexStar

The NexStar can be powered by the supplied 12v AC adapter or eight AA batteries (not included). Batteries should only be used when using the telescope out in the field, where AC power is not available. The battery compartment is located in the center of the telescope's base (see figure 3-1). Before the battery compartment can be removed, the telescope tube must first be moved into a horizontal position. Read the *Hand Control* section below before installing batteries.

To power the NexStar with the 12v AC adapter, simply plug the round post into the 12v outlet on the side of the fork arm and plug the adapter into any wall outlet.

To install the batteries:

1. Remove the battery cover from the center of the base by gently lifting up on the round portion of the cover.
2. Insert the batteries into the battery compartment of the base.
3. Reattach the battery compartment door by gently pushing down on the cover until it snaps into place.
4. Turn on the power to the NexStar by flipping the switch, located next to the 12v outlet, to the "On" position.



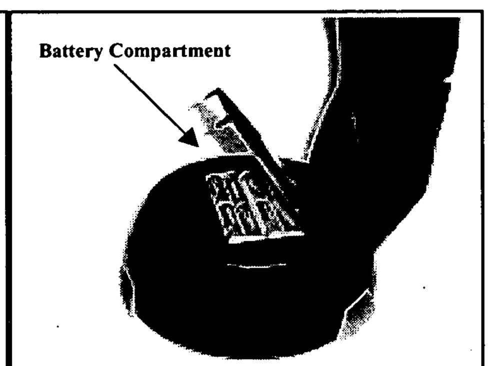


Figure 3-1: The NexStar can be powered by either an AC adapter or with AA batteries.

The Hand Control

The hand control is located on the side of the fork arm and can be removed and used remotely or used while attached to the fork. The hand control attaches to the fork arm by resting on two posts, located on the bottom of the hand control cradle, and a clip inside the fork arm. To remove the hand control from the fork arm cradle, gently lift the hand control upwards and pull out. To return the hand control into the fork arm, lower the hand control into the cradle so that the two holes in the bottom of the hand control go over the posts on the bottom of the cradle, and the opening in the back of the hand control slides over the clip inside the fork arm.

Once the telescope is powered up, use the hand control to move the optical tube to the horizontal position

- Press UNDO. This will bypass the normal alignment procedures and will still allow you to control the telescope.
- Use the Up arrow directional button to move the telescope tube until it is roughly parallel to the ground. This will make it more convenient to attach the necessary accessories as well as remove the front lens cover and install batteries when they are needed.

You are now ready to attach the included visual accessories onto the telescope optical tube.

The Star Diagonal

The star diagonal diverts the light at a right angle from the light path of the telescope. For astronomical observing, this allows you to observe in positions that are more comfortable than if you were to look straight through. To attach the star diagonal:

1. Turn the thumbscrew on the visual back until its tip no longer extends into (i.e., obstructs) the inner diameter of the visual back.
2. Slide the chrome portion of the star diagonal into the visual back.
3. Tighten the thumbscrew on the visual back to hold the star diagonal in place.

If you wish to change the orientation of the star diagonal, loosen the thumbscrew on the visual back until the star diagonal rotates freely Rotate the diagonal to the desired position and tighten the thumbscrew.

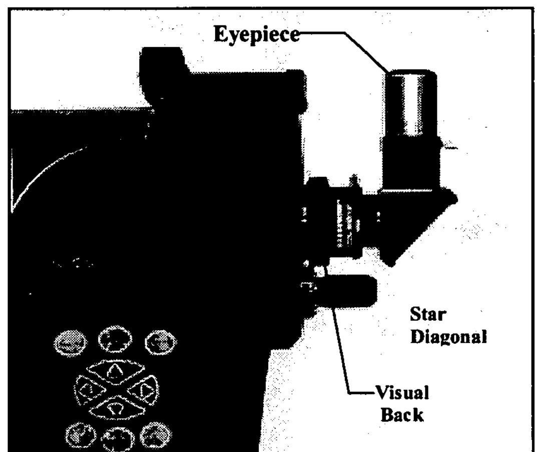


Figure 3-2 - The visual accessories

The Eyepiece

The eyepiece, or ocular, is the optical element that magnifies the image focused by the telescope. The eyepiece fits into either the visual back directly or the star diagonal. To install the eyepiece

1. Loosen the thumbscrew on the star diagonal so it does not obstruct the inner diameter of the eyepiece end of the diagonal.
2. Slide the chrome portion of the eyepiece into the star diagonal.
3. Tighten the thumbscrew to hold the eyepiece in place.

To remove the eyepiece, loosen the thumbscrew on the star diagonal and slide the eyepiece out.

Eyepieces are commonly referred to by focal length and barrel diameter. The focal length of each eyepiece is printed on the eyepiece barrel. The longer the focal length (i.e., the larger the number) the lower the eyepiece power or magnification; and the shorter the focal length (i.e., the smaller the number) the higher the magnification. Generally, you will use low-to-moderate power when viewing. For more information on how to determine power, see the section on "Calculating Magnification."

Barrel diameter is the diameter of the barrel that slides into the star diagonal or visual back. The NexStar uses eyepieces with a standard 1-1/4" barrel diameter.

The Star Pointer Finderscope

The Star Pointer is the quickest and easiest way to point your telescope exactly at a desired object in the sky. It's like having a laser pointer that you can shine directly onto the night sky. The Star Pointer is a zero magnification pointing tool that uses a coated glass window to superimpose the image of a small red dot onto the night sky. While keeping both eyes open when looking through the Star Pointer, simply move your telescope until the red dot, seen through the Star Pointer, merges with the object as seen with your unaided eye. The red dot is produced by a light-emitting diode (LED); it is not a laser beam and will not damage the glass window or your eye. The Star Pointer comes equipped with a variable brightness control, two axes alignment control and two quick-release dovetail mounting brackets (one for the NexStar telescope and one for mounting the Star Pointer on other sized telescopes). Before the Star Pointer is ready to be used, it must be attached to the telescope tube and properly aligned

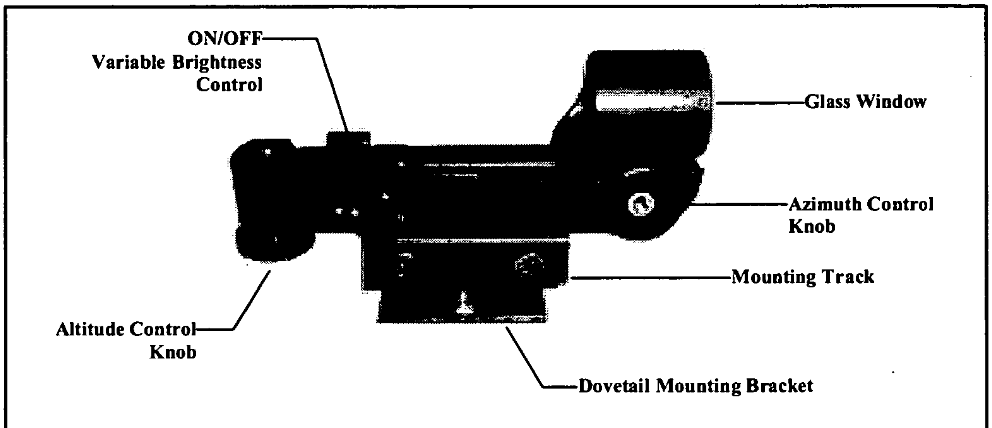


Figure 3-3: The Star Pointer Finderscope with Mounting Bracket

Star Pointer Installation

1. First, remove the two 8-32 x ¼" screws located on the top portion of the telescope's rear cell.
2. Locate the square dovetail bracket that has the proper curvature for the NexStar tube and align the holes with the two holes in the telescope body.
3. Use the two 8-32 x ¼" screws to tighten down the bracket to the rear cell.
4. Once the bracket is mounted, slide the mounting track at the bottom of the Star Pointer over the dovetail portion of the bracket. It may be necessary to loosen the two screws on the side of the mounting track before sliding it over the dovetail. The end of the Star Pointer with the glass window should be facing out towards the front of the telescope.
5. Tighten the two screws on the side of the mounting track to secure the Star Pointer to the dovetail bracket.

Star Pointer Operation

The star pointer is powered by a long life 3-volt lithium battery (#CR2032) located underneath the front portion of the Star Pointer. Like all finderscopes, the Star Pointer must be properly aligned with the main telescope before it can be used. This is a simple process using the azimuth and altitude control knobs located on the side and bottom of the Star Pointer. The alignment procedure is best done at night since the LED dot will be difficult to see during the day.

1. To turn on the Star Pointer, rotate the variable brightness control (see figure 3-3) clockwise until you here a "click". To increase the brightness level of the red dot, continue rotating the control knob about 180° until it stops.

2. Locate a bright star or planet and center it in a low power eyepiece in the main telescope.

3. With both eyes open, look through the glass window at the alignment star.

4. If the Star Pointer is perfectly aligned, you will see the red LED dot overlap the alignment star. If the Star Pointer is not aligned, take notice of where the red dot is relative to the bright star.

5. Without moving the main telescope, turn the Star Pointer's azimuth and altitude alignment controls until the red dot is directly over the alignment star.

If the LED dot is brighter than the alignment star, it may make it difficult to see the star. Turn the variable brightness control counterclockwise, until the red dot is the same brightness as the alignment star. This will make it easier to get an accurate alignment. The Star Pointer is now ready to be used. **Remember to always turn the power off after you have found an object. This will extend the life of both the battery and the LED.**

Hand Control

The NexStar has a removable hand controller built into the side of the fork arm designed to give you instant access to all the functions the NexStar has to offer. With automatic slewing to over 18,000 objects, and common sense menu descriptions, even a beginner can master its variety of features in just a few observing sessions. Below is a brief description of the individual components of the NexStar hand controller:

1. **Liquid Crystal Display (LCD) Window:** Has a dual-line, 16 character display screen that is backlit for comfortable viewing of telescope information and scrolling text.
2. **Align:** Instructs the NexStar to use a selected star or object as an alignment position.
3. **Direction Keys:** Allows complete control of the NexStar in any direction. Use the direction keys to move the telescope to the initial alignment stars or for centering objects in the eyepiece.

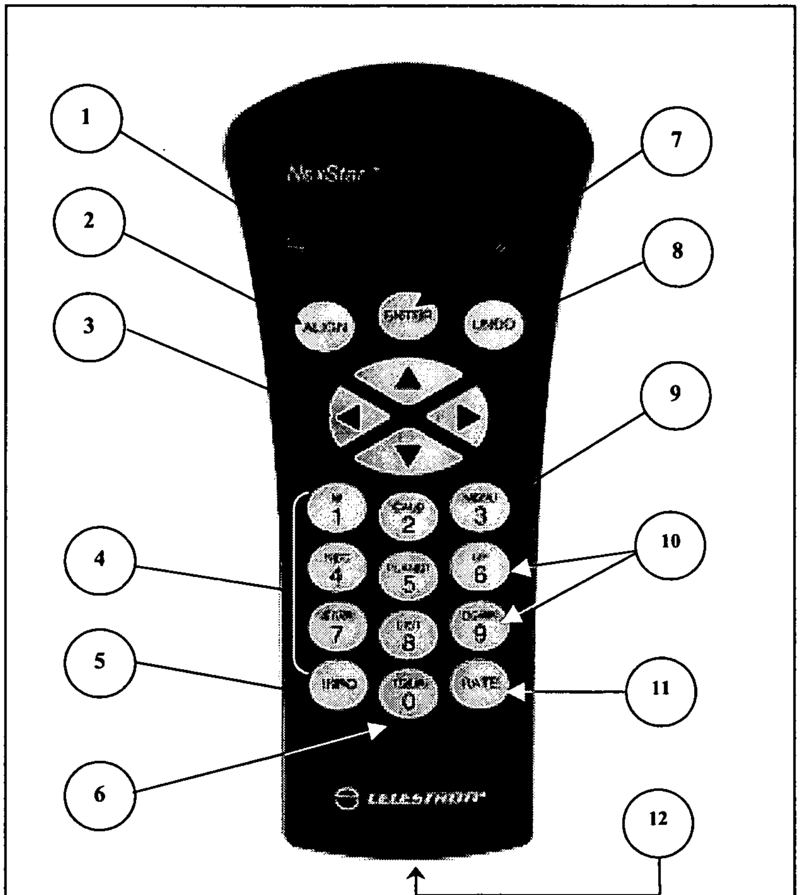


Figure 4-1
The NexStar Hand Control

4. **Catalog Keys:** The NexStar has keys on the hand control to allow direct access to each of the catalogs in its 18,000+ object database. The NexStar contains the following catalogs in its database

Messier – Complete list of all Messier objects.
NGC – Complete list of all the deep-sky objects in the Revised New General Catalog.
Caldwell – A combination of the best NGC and IC objects.
Planets - All 8 planets in our Solar System plus the Sun.
Stars – A compiled list of the brightest stars from the SAO catalog.
List – For quick access, all of the best and most popular objects in the NexStar database have been broken down into lists based on their type and/or common name

Alignment Stars	Common name listing of the brightest stars in the sky.
Named Objects	Alphabetical listing of over 50 of the most popular deep sky objects.
Double Stars	Numeric-alphabetical listing of the most visually stunning double, triple and quadruple stars in the sky.
Variable Stars	Select list of the brightest variable stars with the shortest period of changing magnitude.
Asterisms	A unique list of some of the most recognizable star patterns in the sky.

5. **Info:** Displays coordinates and useful information about objects selected from the NexStar database.
6. **Tour:** Activates the tour mode, which seeks out all the best objects for a given month and automaticall slews the NexStar to those objects.
7. **Enter:** Pressing *Enter* allows you to selects any of the NexStar functions and accept entered parameters.
8. **Undo:** *Undo* will take you out of the current menu and display the previous level of the menu path. Press *Undo* repeatedly to get back to a main menu or use it to erase data entered by mistake.
9. **Menu:** Displays the many setup and utilities functions such as tracking rate and user defined objects and many others.
10. **Scroll Keys:** Used to scroll up and down within any of the menu lists. A double-arrow will appear on the right side of the LCD when there are sub-menus below the displayed menu. Using these keys will scroll through those sub-menus.
11. **Rate:** Instantly changes the rate of speed of the motors when the direction buttons are pressed.
12. **RS-232 Jack:** Allows use with a computer and software programs like *The Sky* for point and click slewing.

Hand Control Operation

This section describes the basic hand control procedures needed to operate the NexStar. These procedures are grouped into three categories: Alignment, Setup and Utilities. The alignment section deals with the initial telescope alignment as well as finding objects in the sk ; the setup section discusses changing parameters such as tracking mode and tracking rate; finally, the last section reviews all of the utilities functions such as the RS-232 connection, activating the cord wrap feature and backlash compensation.

Alignment Procedure

In order for the NexStar to accurately point to objects in the sky, it must first be aligned to two known positions (stars) in the sky. With this information, the telescope can create a model of the sky, which it uses to locate any object with known coordinates. There are two ways to align the NexStar with the sky depending on what information the user is able to provide. If you know the names of two bright, visible stars in the sky, you can use the two-star alignment method; if you do not know the names of two stars in the sky, you can enter the longitude and latitude (provided in Appendix C) of your observing location and NexStar will auto-align itself to two stars in the sky for you.

Two Star Alignment

With the two-star alignment method, the NexStar requires the user to know the positions of only two bright stars in order to accurately align the telescope with the sky and begin finding objects. Once the telescope is powered on, the LCD displa will guide you through all the steps to align the telescope properly. Before the telescope is ready to be aligned, it should be set up in an outside location with all accessories (eyepiece, diagonal and Star Pointer) attached and lens cover removed as described in the *Assembly* section of the manual. Here is an overview of the alignment procedure

1. Once the NexStar is powered on , Press ENTE to begin alignment.
2. Use the Up and Down scroll keys to select `Two Star Align` and press ENTER.
3. The NexStar display will ask you to move the telescope tube until it is horizontal to the ground. To do this, use the direction keys (3) to move the telescope until it is roughly level with the ground. Press ENTER.

4. The SELECT STAR 1 message will appear in the top row of the display. Use the up and down scroll keys (10) to select the star you wish to use for the first alignment star. Press ENTER.
5. NexStar then asks you to center in the eyepiece the alignment star you selected. Use the direction buttons to slew the telescope to the alignment star.

Helpfu Hint

In order to accurately center the alignment star in the eyepiece, it will be necessary to decrease the slew rate of the motors for fine centering. This is done by pressing the RATE key (11) on the hand controller then selecting the number that corresponds to the speed you desire. (9 = fastest, 1 = slowest).

5. Once the alignment star is centered in the field of view of the eyepiece, press the ALIGN key (2) to accept this position.
6. NexStar will then ask you to select and center a second alignment star and press the ALIGN key. It is best to choose alignment stars that are a good distance away from one another. Stars that are at least 40° to 60° apart from each other will give you a more accurate alignment than stars that are close to each other.

Once the second star alignment is completed properly, the display will read **Alignment Successful**, and you will hear the tracking motors turn-on and begin to track.

Auto-Align

Alternatively, if you do not know the names of two bright stars, you can align the telescope by entering the longitude and latitude of your observing location, and the NexStar will automatically choose two stars for alignment and roughly center the stars in the field of view of the Star Pointer. Once again the telescope should be set up outside with all accessories attached and the lens cover removed.

1. Once the NexStar is powered on, Press ENTE to begin alignment.
2. Use the Up and Down scroll keys to select *AutoAlign* if it is not already displayed, and press ENTER.
3. The telescope will then ask you to use the arrow keys (10) to level the telescope tube and point the front of the telescope towards north. North can be found by finding the direction of the North Star (Polaris) or by using a compass. You do not need to point at the North Star, only the north horizon. For help finding the direction of the North Star, see the *Astronomy Basics* section of the manual. Alignment only needs to be approximate, however a close alignment will make the auto alignment more accurate.
4. The hand control display will then ask for the following information

   Date - Enter the month, day and year of your observing session. The display will read mm/dd/yy
   Time - Enter the current local time for your area. You can enter either the local time (i.e. 08:00), or you can enter military time (i.e. 20:00).
   - Select PM or AM. If military time was entered, the hand control will bypass this step.
   - Choose between Standard time or Daylight Savings time. Use the Up and Down scroll buttons (10) to toggle between options.
   - Select the time zone that you are observing from. Again, use the Up and Down buttons (10) to scroll through the choices.

Finally, you must enter the longitude and latitude of the location of your observing site. The coordinates can be obtained from a listing in the appendix of this manual. These coordinates can be saved so that the longitude and latitude only has to be entered once from any given location.

1. Press ENTER at the **Select Location** display
2. Use the Up and Down scroll keys to select **Enter Long/Lat**, if it is not already displayed.
3. Use the table in Appendix C to locate the closest longitude and latitude for your current observing location and enter those numbers when asked in the hand control, pressing ENTER after each entre.

The display will then ask if you would like to save these coordinates for future use. If you press "Yes", the next time you AutoAlign the telescope, you can choose **User Defined** instead of the **Enter Long/Lat**, and enter the number for that observing location. To save the entered longitude and latitude, simply press "Yes" and enter a number from 0-9. Pressing ENTER will assign that number to your current position.

Based on this information, the NexStar will automatically select a bright star that is above the horizon and slew towards it. At this point the telescope is only roughly aligned, so the alignment star should only be close to the field of view of the Star Pointer finder. Once finished slewing, the display will ask you to use the arrow buttons to center the selected star with the red dot in the center of the Star Pointer. If for some reason the chosen star is not visible (perhaps behind a tree or building) you can press UNDO to select and slew to a different star. Once centered in the finder, press ENTER. The display will then instruct you to center the star in the field of view of the eyepiece. When the star is centered, press ALIGN to accept this star

as an alignment star. (There is no need to adjust the slewing rate of the motors after each alignment step. The NexStar automatically selects the best slewing rate for aligning objects in both the Star Pointer and the eyepiece). After the first alignment star has been entered the NexStar will automatically slew to a second alignment star and have you repeat this procedure for that star. When the telescope has been aligned to both stars the display will read " **Alignment Successful**", and you are now ready to find your first object.

Trouble Shooting

If the wrong star was centered and aligned to, the NexStar display will read *Bad Alignment*. Should this occur, the displa will automatically ask you to re-center the last alignment star and press ALIGN. If you believe that the wrong star may have been centered (remember the alignment star will always be the brightest star nearest the field of view of the finder), then re-center the star and press ALIGN. If you wish to try aligning on a different star, press UNDO and the NexStar will select two new alignment stars and automatically slew to the first star.

Third Star Alignment

The NexStar has a third star alignment feature which allows you to replace either of the two original alignment stars with a new star. This can be useful in several situations:

- If you are observing over a period of a few hours, you may notice that your original two alignment stars have drifted towards the west considerably. (Remember that the stars are moving at a rate of 15° every hour). Aligning on a ne star that is in the eastern part of the sky will improve your pointing accuracy, especially on objects in that part of the sky.
- When trying to locate a very faint or small object that may be difficult to find in the eyepiece, you can improve your pointing accuracy by aligning to a third star that is nearest to the object you are trying to find.

To replace an existing alignment star with a new alignment star

1. Locate and center the desired star in the eyepiece.
2. Press the ALIGN key on the hand control.
3. The display will then ask you which alignment star you want to replace.
4. Use the UP and Down scroll keys to select the alignment star to be replaced. It is usually best to replace the star closest to the new star. This will space out your alignment stars across the sky.
5. Press ENTER to make the change.

Object Catalog

Selecting an Object

Now that the telescope is properly aligned, you can choose an object from any of the catalogs in the NexStar's extensive database. The hand control has a key (4) designated for each of the catalogs in its database. There are two ways to select objects from the database: scrolling through the named object lists and entering object numbers.

1. Pressing the LIST key on the hand control will access all objects in the database that have common names or types. Each list is broken down into the following categories: Named Stars, Named Object, Double Stars, Variable Stars and Asterisms. Selecting any one of these options will display a numeric-alphabetical listing of the objects under that list. Pressing the Up and Down keys (10) allows you to scroll through the catalog to the desired object.

Helpful Hint

When scrolling through a long list of objects, holding down either the Up or Down key will allow you to scroll through the catalog at a rapid speed.

2. Pressing any of the other catalog keys (M, CALD, NGC, or STAR) will display a blinking cursor below the name of the catalog chosen. Use the numeric key pad to enter the number of any object within these standardized catalogs. For example, to find the Orion Nebula, press the "M" key and enter "042".

Slewing to an Object

Once the desired object is displayed in the hand control screen, you have two options

1. **Press the INFO Key**. This will give you useful information about the selected object such as R.A. and declination, magnitude and most importantly, altitude above the horizon. (If a star alignment has not yet been performed, the altitude will not be displayed).
2. **Press the ENTER Key**. This will automatically slew the telescope to the coordinates of the object.

Caution: Never slew the telescope when someone is looking into the eyepiece. The telescope can move at very fast slew speeds and may hit an observer in the eye.

Object information can be obtained without having to do a star alignment. After the telescope is powered on, press the UNDO key. Pressing any of the catalog keys allows you to scroll through object lists or enter catalog numbers as described above. However, information such as R.A. and declination of planets and altitude above the horizon will not be displayed unless the telescope is first properly aligned.

There are two special object catalogs which require the input of additional information before the NexStar can slew to the object; they are Planet and Tour:

Finding Planets

Since the planets are not fixed points in the sky, but rather appear to move relative to the background stars, the NexStar needs to have time and date information before it can go to any solar system object. To locate the planets, press the PLANET key on the hand control. The on screen display will ask for the following information

Date - Enter the month, day and year of your observing session.
Time - Enter the current local time for your area.
Select PM or AM.
Choose between Standard time or Daylight Savings time.
Select the time zone that you are observing from.

Once this information is entered, use the Up and Down keys to select the Planet that you wish to observe. Press ENTER.

If *AutoAlign* was used to align the telescope, all the necessary information has already been entered into the hand control and you are ready to select a planet to observe.

Tour Mode

The NexStar includes a tour feature which automatically allows the user to choose from a list of interesting objects based on the month in which you are observing. The Tour mode is activated by pressing the TOUR key (6) on the hand control. Once activated, simply use the scroll keys to select the current month and press ENTER. The NexStar will display from a list of the best objects to observe based on the month entered.

- To see information and data about the displayed object, press the INFO key.
- To slew to the object displayed, press ENTER.
- To see the next tour object, press the Up key

Observing Tip

When going through any of the object catalogs in the database, you can easily find out which objects are above the horizon and visible simply by pressing the INFO button when the desired object is displayed. This will display the objects altitude above the horizon based on the date and time entered. Pressing the UP button once will display any scrolling text associated with that object. The scrolling text can be viewed even if a star alignment has not been performed.

Direction Buttons

The NexStar has four direction buttons in the center of the hand control which control the telescope motion in altitude (up and down) and azimuth (left and right). The telescope can be controlled at nine different speed rates.

Rate Button

Pressing the RATE key (11) allows you to instantly change the speed rate of the motors from high speed slew rate to precise guiding rate or anywhere in between. Each rate corresponds to a number on the hand controller key pad. The number 9 is the fastest rate (6° per second, depending on power source) and is used for slewing between objects and locating alignment stars. The number 1 on the hand control is the slowest rate (1x sidereal) and can be used for accurate centering of objects in the eyepiece and photographic guiding. To change the speed rate of the motors

- Press the RATE key on the hand control. The LCD will display the current speed rate.
- Press the number on the hand control that corresponds to the desired speed. The LCD will display "NexStar Read " indicating that the rate has been changed.

The hand control has a "double button" feature that allows you to instantly speed up the motors without having to choose a speed rate. To use this feature, simply press the arrow button that corresponds to the direction that you want to move the telescope. While holding that button down, press the opposite directional button. This will increase the slew rate to approximately 1.5° per second (equal to rate 7 on the hand control). This feature will not function if the telescope is currently set at a speed rate of 8 or 9.

The slower slew rates (6 and lower) move the motors in the opposite direction than the faster slew rates (8 and 9). This is done so that an object will move in the appropriate direction when looking into the eyepiece (i.e. pressing the right arrow button will move the star towards the right in the field of view of the eyepiece). However, if any of the slower slew rates (rate 6 and below) are used to center an object in the Star Pointer , you may need to press the opposite directional button to make the telescope move in the correct direction.

1 = 1x (sidereal) *2 = 2x* *3 = 8x* *4 = 16x* *5 = 64x*	*6 = 128x* *7 = 1.5°/sec* *8 = 3°/sec* *9 = 6.5°/sec*

Nine available slew speeds

Setup Procedures

The NexStar contains many user defined setup functions designed to give the user control over the telescope's man advanced features. All of the setup and utility features can be accessed by pressing the MENU key and scrolling through the options

Tracking Mode This allows you to change the way the telescope tracks depending on the type of mount being used to support the telescope. The NexStar has three different tracking modes

Alt-Az This is the default tracking rate and is used when the telescope is placed on a flat surface or tripod without the use of an equatorial wedge. The telescope must be aligned with two stars before it can track in Alt-Az.

EQ North Used to track the sky when the telescope is polar aligned using an equatorial wedge in the Northern Hemisphere.

EQ South Used to track the sky when the telescope is polar aligned using an equatorial wedge in the Southern Hemisphere.

Off When using the telescope for terrestrial (land) observation, the tracking can be turned off so that the telescope never moves.

Tracking Rate

In addition to being able to move the telescope with the hand control buttons, the NexStar will continually track a celestial object as it moves across the night sky. The tracking rate can be changed depending on what type of object is being observed

Sidereal This rate compensates for the rotation of the earth by moving the telescope at the same rate as the rotation of the earth, but in the opposite direction. When the telescope is polar aligned, this can be accomplished by moving the telescope in Right Ascension only. When mounted in Alt-Az mode, the telescope must make corrections in both R.A. and declination.

Lunar Used for tracking the moon when observing the lunar landscape.

Solar Used for tracking the Sun when solar observing.

King As light passes through our atmosphere, atmospheric refraction affects the apparent motion of objects across the sky. The King rate takes this into account and compensates for the refraction of the atmosphere.

Date/Time - Allows you to update both the date and the time to improve pointing accuracy on many objects.

User Defined Objects

The NexStar can store up to 25 different user defined objects in its memory. The objects can be daytime land objects or an interesting celestial object that you discover that is not included in the regular database. There are several ways to save an object to memory depending on what type of object it is

Save Sky Object: The NexStar stores celestial objects to its database by saving its right ascension and declination in the sky. This way the same object can be found each time the telescope is aligned. Once a desired object is centered in the eyepiece, simply scroll to the " Save Sky Obj" command and press ENTER. The display will ask you to enter a number between 1-20 to identify the object. Press ENTER again to save this object to the database.

Save Land Object: The NexStar can also be used as a spotting scope on terrestrial objects. Fixed land objects can be stored by saving their altitude and azimuth relative to the location of the telescope at the time of observing. Since these objects are relative to the location of the telescope, the are only valid for that exact location. To save land objects, once again center the desired object in the eyepiece. Scroll down to the " Save Land Obj" command and press ENTER. The display will ask you to enter a number between 21-25 to identify the object. Press ENTER again to save this object to the database.

Enter R.A. - Dec: You can also store a specific set of coordinates for an object just by entering the R.A. and declination for that object. Scroll to the "Enter RA-DEC " command and press ENTER. The display will then ask you to enter first the R.A. and then the declination of the desired object.

GoTo Object: To go to any of the user defined objects stored in the database, scroll down to " GoTo Obj" and enter the number of the object you wish to select and press ENTER. NexStar will automatically retrieve the coordinates and slew to the object.

To replace the contents of any of the user defined objects, simply save a new object using one of the existing identification numbers; NexStar will replace the previous user defined object with the current one.

Get RA/DEC - Displays the right ascension and declination for the current position of the telescope.

Get Alt-A - Displays the relative altitude and azimuth for the current position of the telescope.

Goto R.A/ Dec - Allows you to input a specific R.A. and declination and slew to it.

Goto Alt-A - Allows you to enter a specific altitude and azimuth position and slew to it.

Helpful Hint

To store a set of coordinates (R.A./Dec) permanently into the NexStar database, save it as a *User Defined Object* as described above.

Utility Features

Scrolling through the MENU options will also provide access to several advanced utility functions within the NexStar such as; motor demo, RS-232 interface, key pad light control, cord wrap and anti-backlash.

Demo - This feature will test both the altitude and azimuth motors by slewing to randomly chosen coordinates in the sky.

RS-232 – The NexStar has an RS-232 port allowing it to communicate with many astronomy computer programs (such as *The Sky* by Software Bisque). Before attempting to create a link with a computer or laptop, go to the RS-232 option and press ENTER. Follow the connection procedures outlined by your software instructions.

Light Control – This feature allows you to turn off both the red key pad light and LCD display for daytime use to conserve power and to help preserve your night vision.

Cord Wra – Cord wrap safeguards against the telescope slewing more than 360° in azimuth and wrapping the power cord around the base of the telescope. By default, the cord wrap feature is active when the telescope is powered on. Cord wrap should be turned off when powering the NexStar with batteries.

Anti-backlash – All mechanical gears have a certain amount of backlash or play between the gears. This play is evident by how long it takes for a star to move in the eyepiece when the hand control arrow buttons are pressed (especially when changing directions). The NexStar's anti-backlash features allows the user to compensate for backlash by inputting a value which quickly rewinds the motors just enough to eliminate the play between gears. The amount of compensation needed depends on the slewing rate selected; the slower the slewing rate the longer it will take for the star to appear to move in the eyepiece. Therefore, the anti-backlash compensation will have to be set higher. You will need to experiment with different values; a value between 20 and 50 is usually best for most visual observing, whereas a higher value may be necessary for photographic guiding.

To set the anti-backlash value, scroll down to the anti-backlash option and press ENTER. Enter a value from 0-100 for both azimuth and altitude and press ENTER after each one to save these values. NexStar will remember these values and use them each time it is turned on until they are changed.

Observing Tip

For the best possible pointing accuracy, always center the alignment stars using the up arrow button and the right arrow button. Approaching the star from this direction when looking through the eyepiece will eliminate much of the backlash between the gears and assure the most accurate alignment possible.

NexStar Ready

- **MENU**
  - TRACKING MODE
    - *ALT-AZ*
    - *EQ NORTH*
    - *EQ SOUTH*
    - *OFF*
  - TRACKING RATE
    - *SIDEREAL*
    - *SOLAR*
    - *LUNAR*
    - *KING*
  - GET RA-DEC
  - GET ALT-AZ
  - GOTO RA-DEC
  - GOTO ALT-AZ
  - DEMO
  - RS 232
  - USER OBJECTS
    - *GOTO OBJECT*
    - *SAVE LAND OBJ*
    - *SAVE SKY OBJ*
    - *ENTER RA / DEC*
  - DATE & TIME
  - LIGHTS ON/OFF
    - *DISPLAY OFF*
    - *DISPLAY ON*
    - *KEY PAD OFF*
    - *KEY PAD ON*
  - CORD WRAP
    - *POWER CORD*
    - *BATTERY*
  - ANTI-BACKLASH
- **ALIGNMENT**
  - AUTO ALIGN
    - *POINT TUBE NORTH & LEVEL*
      - *MM/DD/YY*
      - ...
      - ...
      - ...
      - *SELECT LOCATION*
        - *ENTER LONG / LAT*
          - *ENTER LONG*
          - *ENTER LAT*
          - *SAVE LOCATION*
        - *USER DEFINED*
          - *ENTER SAVED LOCATION*
  - TWO-STAR ALIGNMENT
    - *LEVEL TUBE*
      - *SELECT STAR 1*
        - *CENTER STAR 1*
      - *SELECT STAR 2*
        - *CENTER STAR 2*
- **LIST**
  - *NAMED STAR*
  - *NAMED OBJECT*
  - *DOUBLE STAR*
  - *VARIABLE STAR*
  - *ASTERISM*
  - *TOUR*
  - *PLANETS*

NexStar Menu Tree:
The following figure is a menu tree showing the sub-menus associated with the primary command functions

Telescope Basics

A telescope is an instrument that collects and focuses light. The nature of the optical design determines how the light is focused. Some telescopes, known as refractors, use lenses. Other telescopes, known as reflectors, use mirrors. The Schmidt-Cassegrain optical system (or Schmidt-Cass for short) uses a combination of mirrors and lenses and is referred to as a compound or catadioptric telescope. This unique design offers large-diameter optics while maintaining very short tube lengths, making them extremely portable. The Schmidt-Cassegrain system consists of a zero power corrector plate, a spherical primary mirror, and a secondary mirror. Once light rays enter the optical system, they travel the length of the optical tube three times.

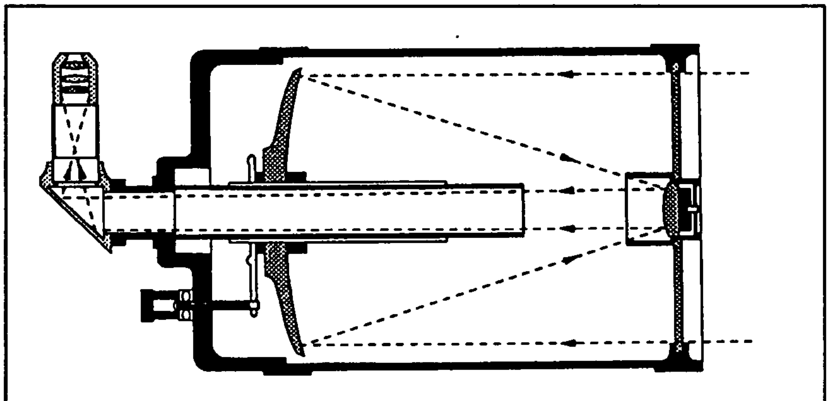


Figure 5-1
A cutaway view of the light path of the Schmidt-Cassegrain optical design

The optics of the NexStar have Starbright coatings - enhanced multi-layer coatings on the primary and secondary mirrors for increased reflectivity and a fully coated corrector for the finest anti-reflection characteristics.

Inside the optical tube, a black tube extends out from the center hole in the primary mirror. This is the primary baffle tube and it prevents stray light from passing through to the eyepiece or camera.

Image Orientation

The image orientation changes depending on how the eyepiece is inserted into the telescope. When using the star diagonal, the image is right-side-up, but reversed from left-to-right (i.e., reverted). If inserting the eyepiece directly into the visual back (i.e., without the star diagonal), the image is upside-down and reversed from left-to-right (i.e., inverted). This is normal for the Schmidt-Cassegrain design.

Actual image orientation as see with the unaided eye

Reversed from left to right, as viewed with a Star Diagonal

Inverted image, as viewed with the eyepiece directly in telescope

Figure 5-2

Focusing

The NexStar's focusing mechanism controls the primary mirror which is mounted on a ring that slides back and forth on the primary baffle tube. The focusing knob, which moves the primary mirror, is on the rear cell of the telescope just below the star diagonal and eyepiece. Turn the focusing knob until the image is sharp. If the knob will not turn, it has reached the end of its travel on the focusing mechanism. Turn the knob in the opposite direction until the image is sharp. Once an image is in focus, turn the knob clockwise to focus on a closer object and counterclockwise for a more distant object. A single turn of the focusing knob moves the primary mirror only slightly. Therefore, it will take many turns (about 30) to go from close focus (approximately 20 feet) to infinity.

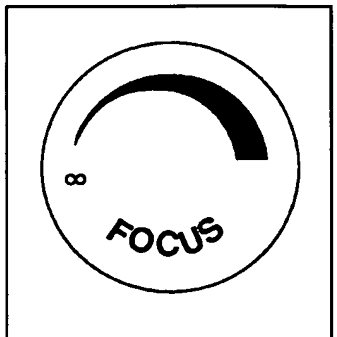


Figure 5-3
The emblem on the end of the focus knob shows the correct rotational direction for focusing the NexStar.

For astronomical viewing, out of focus star images are very diffuse, making them difficult to see. If you turn the focus knob too quickly, you can go right through focus without seeing the image. To avoid this problem, your first astronomical target should be a bright object (like the Moon or a planet) so that the image is visible even when out of focus. Critical focusing is best accomplished when the focusing knob is turned in such a manner that the mirror moves against the pull of gravity. In doing so, any mirror shift is minimized. For astronomical observing, both visually and photographically, this is done by turning the focus knob counterclockwise.

Calculating Magnification

You can change the power of your telescope just by changing the eyepiece (ocular). To determine the magnification of your telescope, simply divide the focal length of the telescope by the focal length of the eyepiece used. In equation format, the formula looks like this

$$\text{Magnification} = \frac{\text{Focal Length of Telescope (mm)}}{\text{Focal Length of Eyepiece (mm)}}$$

Let's say, for example, you are using the 25mm Plossl eyepiece. To determine the magnification you simply divide the focal length of your telescope (the NexStar has a focal length of 1250mm) by the focal length of the eyepiece, 25mm. Dividing 1250 by 25 yields a magnification of 50 power.

Although the power is variable, each instrument under average skies has a limit to the highest useful magnification. The general rule is that 60 power can be used for every inch of aperture. For example, the NexStar is 5" in diameter. Multiplying 5 by 60 gives a maximum useful magnification of 300 power. Although this is the maximum useful magnification, most observing is done in the range of 20 to 35 power for every inch of aperture which is 100 to 175 times for the NexStar telescope.

Determining Field of View

Determining the field of view is important if you want to get an idea of the angular size of the object you are observing. To calculate the actual field of view, divide the apparent field of the eyepiece (supplied by the eyepiece manufacturer) by the magnification. In equation format, the formula looks like this

$$\text{True Field} = \frac{\text{Apparent Field of Eyepiece}}{\text{Magnification}}$$

As you can see, before determining the field of view, you must calculate the magnification. Using the example in the previous section, we can determine the field of view using the same 25mm eyepiece. The 25mm Plossl eyepiece has an apparent field of view of 52°. Divide the 52° by the magnification, which is 50 power. This yields an actual field of 1.04°, or a little over a full degree.

To convert degrees to feet at 1,000 yards, which is more useful for terrestrial observing, simply multiply by 52.5. Continuing with our example, multiply the angular field 1.04° by 52.5. This produces a linear field width of 54.6 feet at a distance of one thousand yards. The apparent field of each eyepiece that Celestron manufactures is found in the Celestron Accessory Catalog (#93685).

General Observing Hints

When working with any optical instrument, there are a few things to remember to ensure you get the best possible image.

- Never look through window glass. Glass found in household windows is optically imperfect, and as a result, may vary in thickness from one part of a window to the next. This inconsistency can and will affect the ability to focus your telescope. In most cases you will not be able to achieve a truly sharp image, while in some cases, you may actually see a double image.

- Never look across or over objects that are producing heat waves. This includes asphalt parking lots on hot summer days or building rooftops.

- Hazy skies, fog, and mist can also make it difficult to focus when viewing terrestrially. The amount of detail seen under these conditions is greatly reduced. Also, when photographing under these conditions, the processed film may come out a little grainier than normal with lower contrast and underexposed.

- If you wear corrective lenses (specifically glasses), you may want to remove them when observing with an eyepiece attached to the telescope. When using a camera, however, you should always wear corrective lenses to ensure the sharpest possible focus. If you have astigmatism, corrective lenses must be worn at all times.

CELESTRON

Astronomy Basics

Up to this point, this manual covered the assembly and basic operation of your NexStar telescope. However, to understand your telescope more thoroughly, you need to know a little about the night sky. This section deals with observational astronomy in general and includes information on the night sky and polar alignment.

The Celestial Coordinate System

To help find objects in the sky, astronomers use a celestial coordinate system that is similar to our geographical coordinate system here on Earth. The celestial coordinate system has poles, lines of longitude and latitude, and an equator. For the most part, these remain fixed against the background stars.

The celestial equator runs 360 degrees around the Earth and separates the northern celestial hemisphere from the southern. Like the Earth's equator, it bears a reading of zero degrees. On Earth this would be latitude. However, in the sky this is referred to as declination, or DEC for short. Lines of declination are named for their angular distance above and below the celestial equator. The lines are broken down into degrees, minutes of arc, and seconds of arc. Declination readings south of the equator carry a minus sign (-) in front of the coordinate and those north of the celestial equator are either blank (i.e., no designation) or preceded by a plus sign (+).

The celestial equivalent of longitude is called Right Ascension, or R.A. for short. Like the Earth's lines of longitude, they run from pole to pole and are evenly spaced 15 degrees apart. Although the longitude lines are separated by an angular distance, they are also a measure of time. Each line of longitude is one hour apart from the next. Since the Earth rotates once every 24 hours, there are 24 lines total. As a result, the R.A. coordinates are marked off in units of time. It begins with an arbitrary point in the constellation of Pisces designated as 0 hours, 0 minutes, 0 seconds. All other points are designated by how far (i.e., how long) they lag behind this coordinate after it passes overhead moving toward the west.

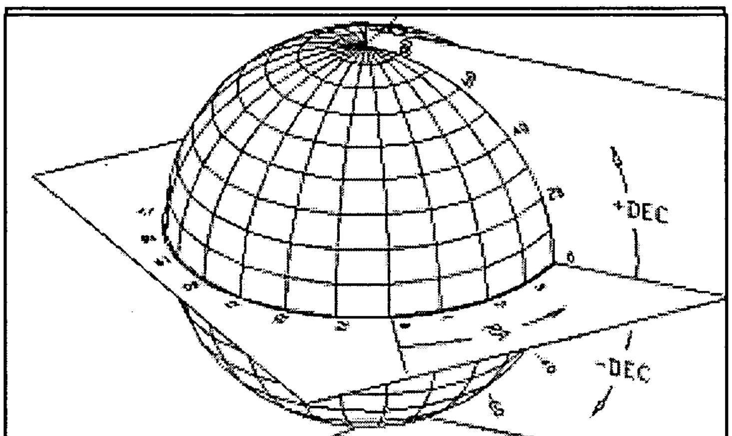


Figure 6-1
The celestial sphere seen from the outside showing R.A. and DEC.

Motion of the Stars

The daily motion of the Sun across the sky is familiar to even the most casual observer. This daily trek is not the Sun moving as early astronomers thought, but the result of the Earth's rotation. The Earth's rotation also causes the stars to do the same, scribing out a large circle as the Earth completes one rotation. The size of the circular path a star follows depends on where it is in the sky. Stars near the celestial equator form the largest circles rising in the east and setting in the west. Moving toward the north celestial pole, the point around which the stars in the northern hemisphere appear to rotate, these circles become smaller. Stars in the mid-celestial latitudes rise in the northeast and set in the northwest. Stars at high celestial latitudes are always above the horizon, and are said to be circumpolar because they never rise and never set. You will never see the stars complete one circle because the sunlight during the day washes out the starlight. However, part of this circular motion of stars in this region of the sky can be seen by setting up a camera on a tripod and opening the shutter for a couple hours. The processed film will reveal semicircles that revolve around the pole. (This description of stellar motions also applies to the southern hemisphere except all stars south of the celestial equator move around the south celestial pole.)

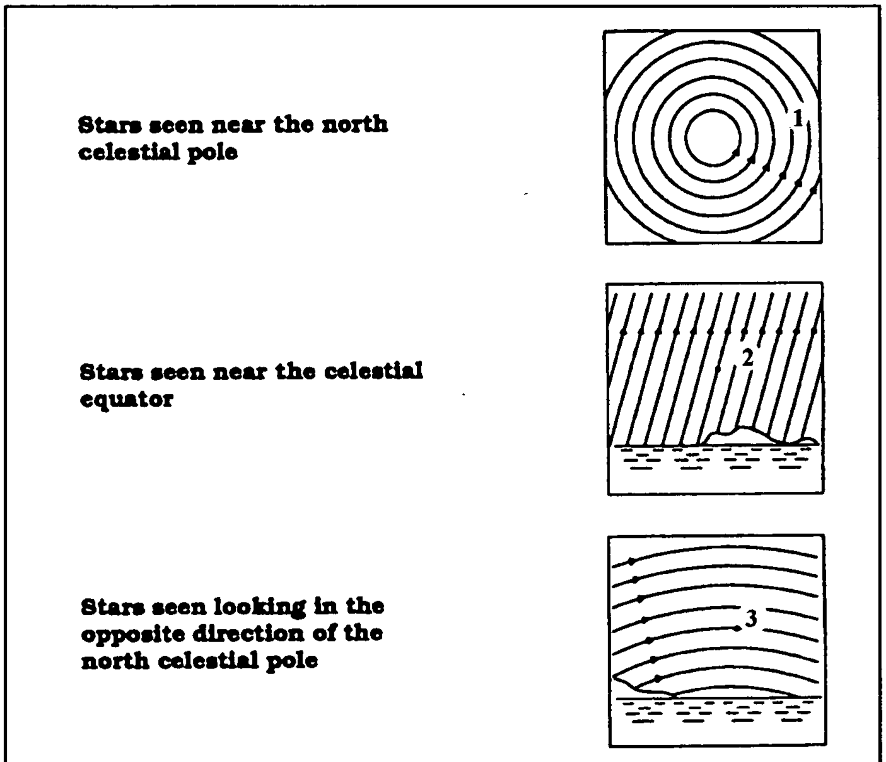


Figure 6-2
All stars appear to rotate around the celestial poles. However, the appearance of this motion varies depending on where you are looking in the sky. Near the north celestial pole the stars scribe out recognizable circles centered on the pole (1). Stars near the celestial equator also follow circular paths around the pole. But, the complete path is interrupted by the horizon. These appear to rise in the east and set in the west (2). Looking toward the opposite pole, stars curve or arc in the opposite direction scribing a circle around the opposite pole (3).

Polar Alignment (with optional Wedge)

Even though the NexStar can precisely track a celestial object while in the Alt-Az position, it is still necessary to align the polar axis of the telescope (the fork arm) to the Earth's axis on rotation in order to do long exposure astro photography. To do an accurate polar alignment, the NexStar requires an optional equatorial wedge between the telescope and a tripod. This allows the telescope's tracking motors to rotate the telescope around the celestial pole, the same way as the stars. Without the equatorial wedge, you would notice the stars in the eyepiece would slowly rotate around the center of the field of view. Although this gradual rotation would go unnoticed when viewing with an eyepiece, it would be very noticeable on film.

Polar alignment is the process by which the telescope's axis of rotation (called the polar axis) is aligned (made parallel) with the Earth's axis of rotation. Once aligned, a telescope with a clock drive will track the stars as they move across the sky. The result is that objects observed through the telescope appear stationary (i.e., they will not drift out of the field of view). If not using the clock drive, all objects in the sky (day or night) will slowly drift out of the field. This motion is caused by the Earth's rotation.

Whether you are using your NexStar in the Alt-Az configuration or polar aligned, it will be necessary to locate where north is and more specifically where the North Star is.

Definition

The polar axis is the axis around which the telescope rotates when moved in right ascension. This axis points the same direction even when the telescope moves in right ascension and declination.

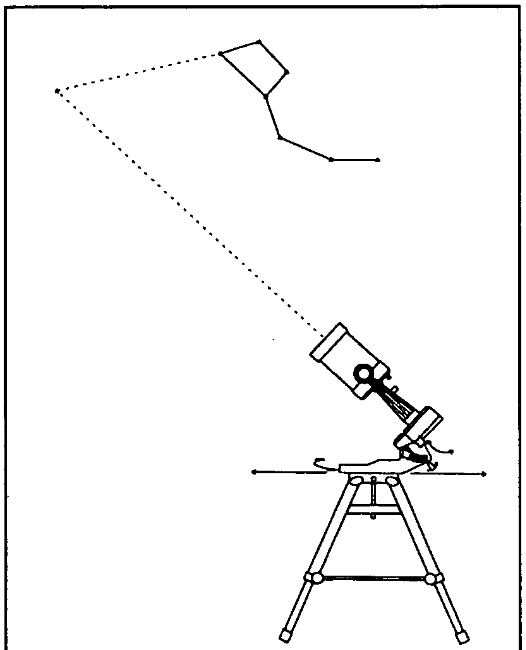


Figure 6-3
This is how the telescope is to be set up for polar alignment. The tube should be parallel to the fork arm and the mount should point to Polaris.

Finding the North Celestial Pole

In each hemisphere, there is a point in the sky around which all the other stars appear to rotate. These points are called the celestial poles and are named for the hemisphere in which they reside. For example, in the northern hemisphere all stars move around the north celestial pole. When the telescope's polar axis is pointed at the celestial pole, it is parallel to the Earth's rotational axis.

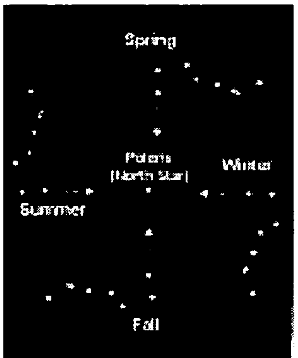


Figure 6-4 – The position of the Big Dipper changes throughout the year and the night.

Many methods of polar alignment require that you know how to find the celestial pole by identifying stars in the area. For those in the northern hemisphere, finding the celestial pole is not too difficult. Fortunately, we have a naked eye star less than a degree away. This star, Polaris, is the end star in the handle of the Little Dipper. Since the Little Dipper (technically called Ursa Minor) is not one of the brightest constellations in the sky, it may be difficult to locate from urban areas. If this is the case, use the two end stars in the bowl of the Big Dipper (the pointer stars). Draw an imaginary line through them toward the Little Dipper. They point to Polaris (see Figure 6-5). The position of the Big Dipper changes during the year and throughout the course of the night (see Figure 6-4). When the Big Dipper is low in the sky (i.e., near the horizon), it may be difficult to locate. During these times, look for Cassiopeia (see Figure 6-5). Observers in the southern hemisphere are not as fortunate as those in the northern hemisphere. The stars around the south celestial pole are not nearly as bright as those around the north. The closest star that is relatively bright is Sigma Octantis. This star is just within naked eye limit (magnitude 5.5) and lies about 59 arc minutes from the pole.

Definition

The north celestial pole is the point in the northern hemisphere around which all stars appear to rotate. The counterpart in the southern hemisphere is referred to as the south celestial pole.

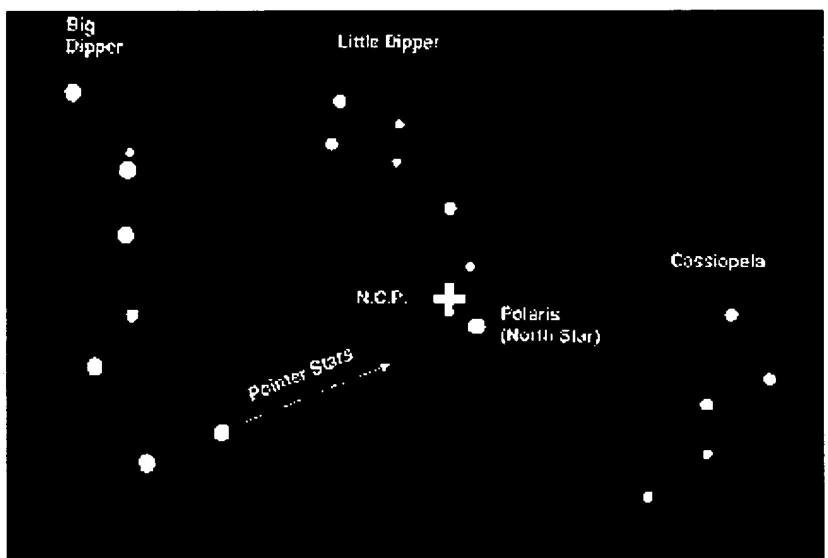
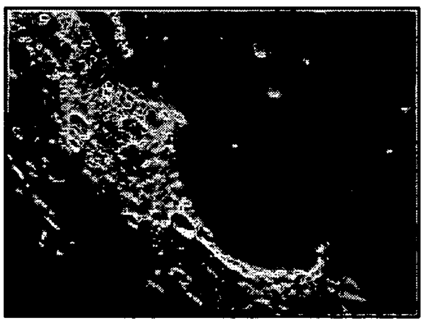


Figure 6-5
The two stars in the front of the bowl of the Big Dipper point to Polaris which is less than one degree from the true (north) celestial pole. Cassiopeia, the "W" shaped constellation, is on the opposite side of the pole from the Big Dipper. The North Celestial Pole (N.C.P.) is marked by the "+" sign.

Celestial Observing

With your telescope set up, you are ready to use it for observing. This section covers visual observing hints for both solar system and deep sky objects as well as general observing conditions which will affect your ability to observe.

Observing the Moon



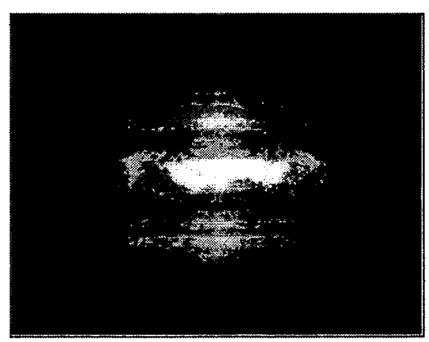
Often, it is tempting to look at the Moon when it is full. At this time, the face we see is fully illuminated and its light can be overpowering. In addition, little or no contrast can be seen during this phase.

One of the best times to observe the Moon is during its partial phases (around the time of first or third quarter). Long shadows reveal a great amount of detail on the lunar surface. At low power you will be able to see most of the lunar disk at one time. The optional Reducer/Corrector lens allows for breath-taking views of the entire lunar disk when used with a low power eyepiece. Change to higher power (magnification) to focus in on a smaller area. Choose the *lunar* tracking rate from the NexStar's MENU tracking rate options to keep the moon centered in the eyepiece even at high magnifications.

Lunar Observing Hints

- To increase contrast and bring out detail on the lunar surface, use filters. A yellow filter works well at improving contrast while a neutral density or polarizing filter will reduce overall surface brightness and glare.

Observing the Planets



Other fascinating targets include the five naked eye planets. You can see Venus go through its lunar-like phases. Mars can reveal a host of surface detail and one, if not both, of its polar caps. You will be able to see the cloud belts of Jupiter and the great Red Spot (if it is visible at the time you are observing). In addition, you will also be able to see the moons of Jupiter as they orbit the giant planet. Saturn, with its beautiful rings, is easily visible at moderate power.

Planetary Observing Hints

- Remember that atmospheric conditions are usually the limiting factor on how much planetary detail will be visible. So, avoid observing the planets when they are low on the horizon or when they are directly over a source of radiating heat, such as a rooftop or chimney. See the "*Seeing Conditions*" section later in this section.
- To increase contrast and bring out detail on the planetary surface, try using Celestron eyepiece filters.

Observing the Sun

Although overlooked by many amateur astronomers, solar observation is both rewarding and fun. However, because the Sun is so bright, special precautions must be taken when observing our star so as not to damage your eyes or your telescope.

Never project an image of the Sun through the telescope. Because of the folded optical design, tremendous heat build-up will result inside the optical tube. This can damage the telescope and/or any accessories attached to the telescope.

For safe solar viewing, use a solar filter that reduces the intensity of the Sun's light, making it safe to view. With a filter you can see sunspots as they move across the solar disk and faculae, which are bright patches seen near the Sun's edge.

Solar Observing Hints

- The best time to observe the Sun is in the early morning or late afternoon when the air is cooler.
- To center the Sun without looking into the eyepiece, watch the shadow of the telescope tube until it forms a circular shadow.
- To ensure accurate tracking, be sure to select solar tracking rate.

Observing Deep Sky Objects

Deep-sky objects are simply those objects outside the boundaries of our solar system. They include star clusters, planetary nebulae, diffuse nebulae, double stars and other galaxies outside our own Milky Way. Most deep-sky objects have a large angular size. Therefore, low-to-moderate power is all you need to see them. Visually, they are too faint to reveal any of the color seen in long exposure photographs. Instead, they appear black and white. And, because of their low surface brightness, they should be observed from a dark-sky location. Light pollution around large urban areas washes out most nebulae making them difficult, if not impossible, to observe. Light Pollution Reduction filters help reduce the background sky brightness, thus increasing contrast.

Seeing Conditions

Viewing conditions affect what you can see through your telescope during an observing session. Conditions include transparency, sky illumination, and seeing. Understanding viewing conditions and the effect they have on observing will help you get the most out of your telescope.

Transparency

Transparency is the clarity of the atmosphere which is affected by clouds, moisture, and other airborne particles. Thick cumulus clouds are completely opaque while cirrus can be thin, allowing the light from the brightest stars through. Hazy skies absorb more light than clear skies making fainter objects harder to see and reducing contrast on brighter objects. Aerosols ejected into the upper atmosphere from volcanic eruptions also affect transparency. Ideal conditions are when the night sky is inky black.

Sky Illumination

General sky brightening caused by the Moon , aurorae, natural airglow, and light pollution greatly affect transparency. While not a problem for the brighter stars and planets, bright skies reduce the contrast of extended nebulae making them difficult, if not impossible, to see. To maximize your observing, limit deep sky viewing to moonless nights far from the light polluted skies found around major urban areas. LPR filters enhance deep sky viewing from light polluted areas by blocking unwanted light while transmitting light from certain deep sky objects. You can, on the other hand, observe planets and stars from light polluted areas or when the Moon is out.

Seeing

Seeing conditions refers to the stability of the atmosphere and directly affects the amount of fine detail seen in extended objects. The air in our atmosphere acts as a lens which bends and distorts incoming light rays. The amount of bending depends on air density. Varying temperature layers have different densities and, therefore, bend light differently. Light rays from the same object arrive slightly displaced creating an imperfect or smeared image. These atmospheric disturbances vary from time-to-time and place-to-place. The size of the air parcels compared to your aperture determines the "seeing" quality. Under good seeing conditions, fine detail is visible on the brighter planets like Jupiter and Mars, and stars are pinpoint images. Under poor seeing conditions, images are blurred and stars appear as blobs.

The conditions described here apply to both visual and photographic observations.

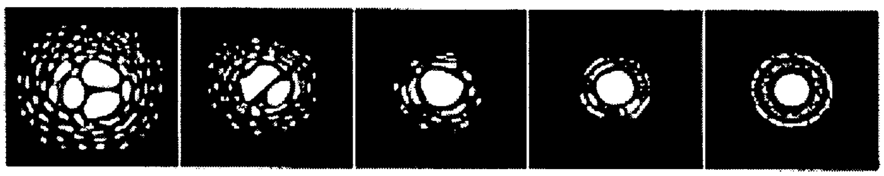


Figure 7-1
Seeing conditions directly affect image quality. These drawing represent a point source (i.e., star) under bad seeing conditions (left) to excellent conditions (right). Most often, seeing conditions produce images that lie some where between these two extremes.

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Celestial Photography

After looking at the night sky for a while you may want to try photographing it. Several forms of celestial photograph are possible with your telescope, including short exposure prime focus, eyepiece projection, long exposure deep sky, terrestrial and even CCD imaging. Each of these is discussed in moderate detail with enough information to get you started. Topics include the accessories required and some simple techniques. More information is available in some of the publications listed at the end of this manual.

In addition to the specific accessories required for each type of celestial photography, there is the need for a camera - but not just any camera. The camera does not have to have many of the features offered on today's state-of-the-art equipment. For example, you don't need auto focus capability or mirror lock up. Here are the mandatory features a camera needs for celestial photography. First, a "B" setting which allows for time exposures. This excludes point and shoot cameras and limits the selection to SLR cameras, the most common type of 35mm camera on the market today.

Second, the "B" or manual setting should NOT run off the battery. Many new electronic cameras use the battery to keep the shutter open during time exposures. Once the batteries are drained, usually after a few minutes, the shutter closes, whether you were finished with the exposure or not. Look for a camera that has a manual shutter when operating in the time exposure mode. Olympus, Nikon, Minolta, Pentax, Canon and others have made such camera bodies.

The camera must have interchangeable lenses so you can attach it to the telescope and so you can use a variety of lenses for piggyback photography. If you can't find a new camera, you can purchase a used camera body that is not 100-percent functional. The light meter, for example, does not have to be operational since you will be determining the exposure length manually.

You also need a cable release with a locking function to hold the shutter open while you do other things. Mechanical and air release models are available.

Short Exposure Prime Focus Photography

Short exposure prime focus photography is the best way to begin recording celestial objects. It is done with the camera attached to the telescope without an eyepiece or camera lens in place. To attach your camera you need the Celestron T-Adapter (#93633-A) and a T-Ring for your specific camera (i.e., Minolta, Nikon, Pentax, etc.). The T-Ring replaces the 35mm SLR camera's normal lens. Prime focus photography allows you to capture the majority of the lunar disk or solar disk. To attach your camera to your telescope.

1. Remove all visual accessories.
2. Thread the T-Ring onto the T-Adapter.
3. Mount your camera body onto the T-Ring the same as you would any other lens.
4. Thread the T-Adapter onto the back of the telescope while holding the camera in the desired orientation (either vertical or horizontal).

With your camera attached to the telescope, you are ready for prime focus photography. Start with an easy object like the Moon. Here's how to do it

1. Load your camera with film that has a moderate-to-fast speed (i.e., ISO rating). Faster films are more desirable when the Moon is a crescent. When the Moon is near full, and at its brightest, slower films are more desirable. Here are some film recommendations

- T-Max 100
- T-Max 400
- Any 100 to 400 ISO color slide film
- Fuji Super HG 400
- Ektar 25 or 100

1. Center the Moon in the field of your NexStar telescope.
2. Focus the telescope by turning the focus knob until the image is sharp.
3. Set the shutter speed to the appropriate setting (see table below).
4. Trip the shutter using a cable release.
5. Advance the film and repeat the process.

Lunar Phase	ISO 50	ISO 100	ISO 200	ISO 400
Crescent	1/2	1/4	1/8	1/15
Quarter	1/15	1/30	1/60	1/125
Full	1/30	1/60	1/125	1/250

Table 8-1
Above is a listing of recommended exposure times when photographing the Moon at the prime focus of your NexStar telescope.

The exposure times listed in table 8-1 should be used as a starting point. Always make exposures that are longer and shorter than the recommended time. Also, take a few photos at each shutter speed. This will ensure that you will get a good photo.

If using black and white film, try a yellow filter to reduce the light intensity and to increase contrast.

Keep accurate records of your exposures. This information is useful if you want to repeat your results or if you want to submit some of your photos to various astronomy magazines for possible publication

This technique is also used for photographing the Sun with the proper solar filter.

Eyepiece Projection

This form of celestial photography is designed for objects with small angular sizes, primarily the Moon and planets. Planets, although physically quite large, appear small in angular size because of their great distances. Moderate to high magnification is, therefore, required to make the image large enough to see any detail. Unfortunately, the camera/telescope combination alone does not provide enough magnification to produce a usable image size on film. In order to get the image large enough, you must attach your camera to the telescope with the eyepiece in place. To do so, you need two additional accessories; a deluxe tele-extender (#93643), which attaches to the visual back, and a T-ring for your particular camera make (i.e., Minolta, Nikon, Pentax, etc.).

Because of the high magnifications during eyepiece projection, the field of view is quite small which makes it difficult to find and center objects. To make the job a little easier, align the finder as accurately as possible. This allows you to get the object in the telescope's field based on the finder's view alone.

Another problem introduced by the high magnification is vibration. Simply tripping the shutter — even with a cable release — produces enough vibration to smear the image. To get around this, use the camera's self-timer if the exposure time is less than one second — a common occurrence when photographing the Moon. For exposures over one second, use the "hat trick." This technique incorporates a hand-held black card placed over the aperture of the telescope to act as a shutter. The card prevents light from entering the telescope while the shutter is released. Once the shutter has been released and the vibration has diminished (a few seconds), move the black card out of the way to expose the film. After the exposure is complete, place the card over the front of the telescope and close the shutter.

Advance the film and you're ready for your next shot. Keep in mind that the card should be held a few inches in front of the telescope, and not touching it. It is easier if you use two people for this process; one to release the camera shutter and one to hold the card. Here's the process for making the exposure.

1. Find and center the desired target in the viewfinder of your camera.
2. Turn the focus knob until the image is as sharp as possible.
3. Place the black card over the front of the telescope.
4. Release the shutter using a cable release.
5. Wait for the vibration caused by releasing the shutter to diminish. Also, wait for a moment of good seeing.
6. Remove the black card from in front of the telescope for the duration of the exposure (see accompanying table).
7. Replace the black card over the front of the telescope.
8. Close the camera's shutter.

Advance the film and you are ready for your next exposure. Don't forget to take photos of varying duration and keep accurate records of what you have done. Record the date, telescope, exposure duration, eyepiece, f/ratio, film, and some comments on the seeing conditions.

The following table lists exposures for eyepiece projection with a 10mm eyepiece. All exposure times are listed in seconds or fractions of a second.

Planet	ISO 50	ISO 100	ISO 200	ISO 400
Moon	4	2	1	1/2
Mercury	16	8	4	2
Venus	1/2	1/4	1/8	1/15
Mars	16	8	4	2
Jupiter	8	4	2	1
Saturn	16	8	4	2

Table 8-2
Recommended exposure time for photographing planets.

The exposure times listed here should be used as a starting point. Always make exposures that are longer and shorter than the recommended time. Also, take a few photos at each shutter speed. This will ensure that you get a good photo. It is not uncommon to go through an entire roll of 36 exposures and have only one good shot.

NOTE: Don't expect to record more detail than you can see visually in the eyepiece at the time you are photographing.

Once you have mastered the technique, experiment with different films, different focal length eyepieces, and even different filters.

Long Exposure Prime Focus Photography

This is the last form of celestial photography to be attempted after others have been mastered. It is intended primarily for deep sky objects, that is objects outside our solar system which includes star clusters, nebulae, and galaxies. While it may seem that high magnification is required for these objects, just the opposite is true. Most of these objects cover large angular areas and fit nicely into the prime focus field of your telescope. The brightness of these objects, however, requires long exposure times and, as a result, are rather difficult.

There are several techniques for this type of photography, and the one chosen will determine the standard accessories needed. The best method for long exposure deep sky astro photography is with an off-axis guider. This device allows

you to photograph and guide through the telescope simultaneously. Celestron offers a very special and advanced off-axis guider, called the Radial Guider (#94176). In addition, you will need a T-Ring to attach your camera to the Radial Guider.

Other equipment needs include a guiding eyepiece. Unlike other forms of astro photography which allows for fairly loose guiding, prime focus requires meticulous guiding for long periods. To accomplish this you need a guiding ocular with an illuminated reticle to monitor your guide star. For this purpose, Celestron offers the Micro Guide Eyepiece (#94171) Here is a brief summary of the technique.

1. Polar align the telescope using an optional equatorial wedge.
2. Remove all visual accessories.
3. Thread the Radial Guider onto your telescope.
4. Thread the T-Ring onto the Radial Guider.
5. Mount your camera body onto the T-Ring the same as you would any other lens.
6. Set the shutter speed to the "B" setting.
7. Focus the telescope on a star.
8. Center your subject in the field of your camera.
9. Find a suitable guide star in the telescope field. This can be the most time consuming process.
10. Open the shutter using a cable release.
11. Monitor your guide star for the duration of the exposure using the buttons on the hand controller to make the needed corrections.
12. Close the camera's shutter.

When getting started, use fast films to record as much detail in the shortest possible time. Here are proven recommendations

- Ektar 1000 (color print)
- Konica 3200 (color print)
- Fujichrome 1600D (color slide)
- 3M 1000 (color slide)
- Scotchchrome 400
- T-Max 3200 (black and white print)
- T-Max 400 (black and white print)

As you perfect your technique, try specialized films, that is films that are designed or specially treated for celestial photography. Here are some popular choices

- Ektar 125 (color print)
- Fujichrome 100D (color slide)
- Tech Pan, gas hypered (black and white print)
- T-Max 400 (black and white print)

There is no exposure determination table to help you get started. The best way to determine exposure length is look at previously published photos to see what film/exposure combinations were used. Or take unguided sample photos of various parts of the sky while the drive is running. Always take exposures of various lengths to determine the best exposure time.

Terrestrial Photography

Your NexStar makes an excellent 1250mm telephoto lens for terrestrial (land) photography. Terrestrial photography is best done will the telescope in Alt-Az configuration and the tracking drive turned off. To turn the tracking drive off, press the MENU (9) button on the hand control and scroll down to the *Tracking Mode* sub menu. Use the Up and Down scroll keys (10) to select the *Off* option and press ENTER. This will turn the tracking motors off, so that objects will remain in your camera's field of view.

Metering

The NexStar has a fixed aperture and, as a result, fixed f/ratios. To properly expose your subjects photographically, you need to set your shutter speed accordingly. Most 35mm SLR cameras offer through-the-lens metering which lets you know if your picture is under or overexposed. Adjustments for proper exposures are made by changing the shutter speed. Consult your camera manual for specific information on metering and changing shutter speeds.

Reducing Vibration

Releasing the shutter manually can cause vibrations, producing blurred photos. To reduce vibration when tripping the shutter, use a cable release. A cable release keeps your hands clear of the camera and lens, thus eliminating the possibility of introducing vibration. Mechanical shutter releases can be used, though air-type releases are best.
Blurry pictures can also result from shutter speeds that are too slow. To prevent this, use films that produce shutter speeds greater than 1/250 of a second when hand-holding the lens. If the lens is mounted on a tripod, the exposure length is virtually unlimited.

Another way to reduce vibration is with the Vibration Suppression Pads (#93503). These pads rest between the ground and tripod feet. They reduce the vibration amplitude and vibration time.

CCD Imaging

CCD Imaging is the most challenging form of astro photography and involves the use of a CCD (Charged Coupled Device) camera attached to the telescope at prime focus. The benefits of CCD imaging is the extreme light sensitivit of the electronic chip inside the camera. This allows you to record much fainter detail in a shorter period of time than would be possible with film photography. Due to the relative small size of the CCD chip, the field of view when imaging will be less than the field of view of a film camera. Using Celestron's optional f/6.3 Reducer/Corrector accessory in conjunction with a CCD camera (or film camera) will greatly increase the photographic field of view and will make finding and tracking a celestial object much easier.

CELESTRON Telescope Maintenance

While your NexStar telescope requires little maintenance, there are a few things to remember that will ensure your telescope performs at its best.

Care and Cleaning of the Optics

Occasionally, dust and/or moisture may build up on the corrector plate of your telescope. Special care should be taken when cleaning any instrument so as not to damage the optics.

If dust has built up on the corrector plate, remove it with a brush (made of camel's hair) or a can of pressurized air. Spray at an angle to the lens for approximately two to four seconds. Then, use an optical cleaning solution and white tissue paper to remove any remaining debris. Apply the solution to the tissue and then apply the tissue paper to the lens. Low pressure strokes should go from the center of the corrector to the outer portion. **Do NOT rub in circles!**

You can use a commercially made lens cleaner or mix your own. A good cleaning solution is isopropyl alcohol mixed with distilled water. The solution should be 60% isopropyl alcohol and 40% distilled water. Or, liquid dish soap diluted with water (a couple of drops per one quart of water) can be used.

Occasionally, you may experience dew build-up on the corrector plate of your telescope during an observing session. If you want to continue observing, the dew must be removed, either with a hair dryer (on low setting) or by pointing the telescope at the ground until the dew has evaporated.

If moisture condenses on the inside of the corrector, remove the accessories from the rear cell of the telescope. Place the telescope in a dust-free environment and point it down. This will remove the moisture from the telescope tube.

To minimize the need to clean your telescope, replace all lens covers once you have finished using it. Since the rear cell is NOT sealed, the cover should be placed over the opening when not in use. This will prevent contaminants from entering the optical tube.

Internal adjustments and cleaning should be done only by the Celestron repair department. If your telescope is in need of internal cleaning, please call the factory for a return authorization number and price quote.

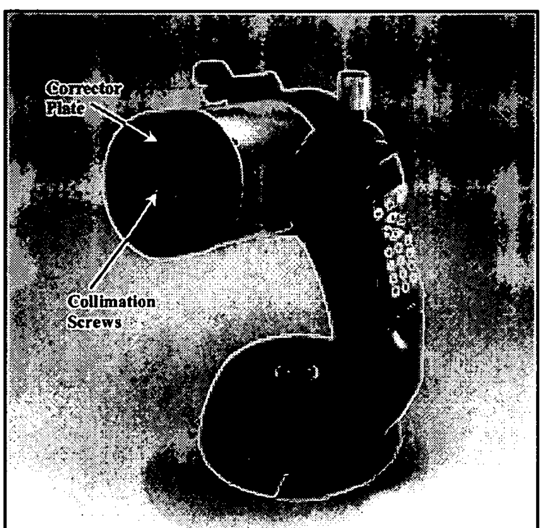


Figure 9-1
The three collimation screws are located on th secondary mirror holder in the center of the corrector plate.

Collimation

The optical performance of your NexStar telescope is directly related to its collimation, that is the alignment of its optical system. Your NexStar was collimated at the factory after it was completel assembled. However, if the telescope is dropped or jarred severel during transport, it may have to be collimated. The only optical element that may need to be adjusted, or is possible, is the tilt of the secondary mirror.

To check the collimation of your telescope you will need a light source. A bright star near the zenith is ideal since there is a minimal amount of atmospheric distortion. Make sure that tracking is on so that you won't have to manually track the star. Or, if you do not want to power up your telescope, you can use Polaris. Its position relative to the celestial pole means that it moves very little thus eliminating the need to manually track it.

Before you begin the collimation process, be sure that your telescope is in thermal equilibrium with the surroundings. Allow 45 minutes for the telescope to reach equilibrium if you move it between large temperature extremes.

To verify collimation, view a star near the zenith. Use a medium to high power ocular — 12mm to 6mm focal length. It is important to center a star in the center of the field to judge collimation. Slowly cross in and out of focus and judge the symmetry of the star. If you see a systematic skewing of the star to one side, then recollimation is needed.

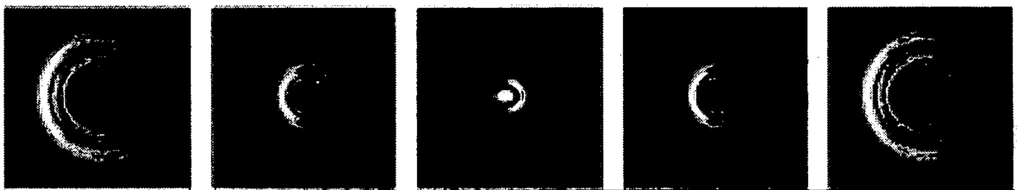


Figure 9-2 – Even though the star pattern appears the same on both sides of focus, they are asymmetric. The dark obstruction is skewed off to the left side of the diffraction pattern indicating poor collimation.

To accomplish this, you need to tighten the secondary collimation screw(s) that move the star across the field toward the direction of the skewed light. These screws are located in the secondary mirror holder (see figure 9-1). Make only a small 1/6 to 1/8 field correction and re-center the star by moving the scope before making any improvements or before making further adjustments.

To make collimation a simple procedure, follow these easy steps

1. While looking through a medium to high power eyepiece, de-focus a bright star until a ring pattern with a dark shadow appears (see figure 9-2). Center the de-focused star and notice in which direction the central shadow is skewed.

2. Place your finger along the edge of the front cell of the telescope (be careful not to touch the corrector plate), pointing towards the collimation screws. The shadow of your finger should be visible when looking into the eyepiece. Rotate your finger around the tube edge until its shadow is seen closest to the narrowest portion of the rings (i.e. the same direction in which the central shadow is skewed).

3. Locate the collimation screw closest to where your finger is positioned. This will be the collimation screw you will need to adjust first. (If your finger is positioned exactly between two of the collimation screws, then you will need to adjust the screw opposite where your finger is located).

4. Use the hand control buttons to move the de-focused star image to the edge of the field of view, in the same direction that the central obstruction of the star image is skewed.

5. While looking through the eyepiece, use an Allen wrench to turn the collimation screw you located in step 2 and 3. Usuall a tenth of a turn is enough to notice a change in collimation. If the star image moves out of the field of view in the direction that the central shadow is skewed, than you are turning the collimation screw the wrong way. Turn the screw in the opposite direction, so that the star image is moving towards the center of the field of view.

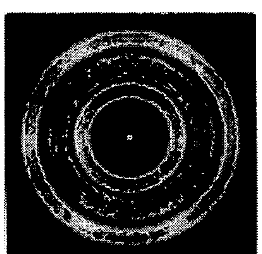


Figure 9-3
A collimated telescope should appear symmetrical with the central obstruction centered in the star's diffraction pattern.

6. If while turning you notice that the screws get very loose, then simply tighten the other two screws by the same amount. Conversely, if the collimation screw gets too tight, then loosen the other two screws by the same amount.

7. Once the star image is in the center of the field of view, check to see if the rings are concentric. If the central obstruction is still skewed in the same direction, then continue turning the screw(s) in the same direction. If you find that the ring pattern is skewed in a different direction, than simply repeat steps 2 through 6 as described above for the new direction.

Perfect collimation will yield a star image very symmetrical just inside and outside of focus. In addition, perfect collimation delivers the optimal optical performance specifications that your telescope is built to achieve.

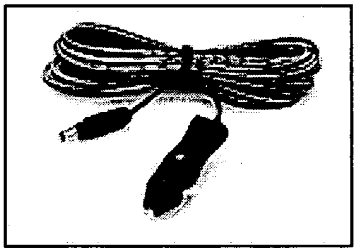
If seeing (i.e., air steadiness) is turbulent, collimation is difficult to judge. Wait until a better night if it is turbulent or aim to a steadier part of the sky. A steadier part of the sky is judged by steady versus twinkling stars.

CELESTRON

Optional Accessories

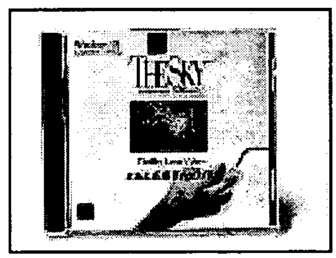
You will find that additional accessories enhance your viewing pleasure and expand the usefulness of you telescope. For ease of reference, all the accessories are listed in alphabetical order.

Adapter, Car Battery (#18769) - Celestron offers the Car Battery Adapter that allows you to run the NexStar drive off an external power source. The adapter attaches to the cigarette lighter of your car, truck, van, or motorcycle.



Barlow Lens - A Barlow lens is a negative lens that increases the focal length of a telescope. Used with any eyepiece, it doubles the magnification of that eyepiece. Celestron offers two Barlow lens in the 1-1/4" size for the NexStar. The 2x Ultima Barlow (#93506) is a compact triplet design that is fully multicoated for maximum light transmission and parfocal when use with the Ultima eyepieces. Model #93507 is a compact achromatic Barlow lens that is under three inches long and weighs only 4 oz. It works very well with all Celestron eyepieces.

Carrying Case (#302070) - This rugged case is constructed of space age resin, making it waterproof, unbreakable, airtight and extremely durable. It's designed so your telescope can be packed with the standard finderscope in place, a convenience you'll be sure to appreciate. The case is lined with die cut foam for custom fitting. It features large handles and is equipped with wheels, for easy transportation. Weight: 17 lbs. (31.5"x 21.75"x 11.5").



CD-ROM (#93700) - Celestron and Software Bisque have joined together to present this comprehensive CD-ROM calle *The Sky™ Level 1 - from Celestron.* It features a 10,000 object database, 75 color images, horizontal projection, custom sky chart printing, zoom capability and more! A fun, useful and educational product. PC format.

Erect Image Diagonal (#94112-A) - This accessory is an Amici prism arrangement that allows you to look into the telescope at a 45° angle with images that are oriented properly (upright and correct from left-to-right). It is useful for daytime, terrestria viewing.

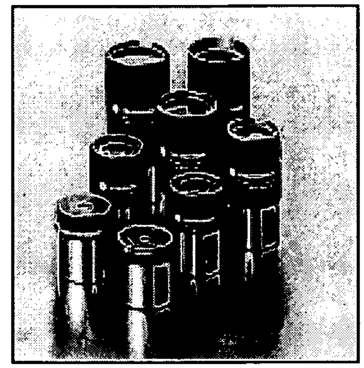
Eyepieces - Like telescopes, eyepieces come in a variety of designs. Each design has its own advantages and disadvantages. For the 1-1/4" barrel diameter there are four different eyepiece designs available.

- **Super Modified Achromatic (SMA) Eyepieces: 1 $^{1}/_{4}$"**

  The SMA design is an improved version of the Kellner eyepiece. SMAs are very good, economical, general purpose eyepieces that deliver a wide apparent field, good color correction and an excellent image at the center of the field of view. Celestron offers SMA eyepieces in 1-1/4" sizes in the following focal lengths: 6mm, 10mm, 12mm, 17mm and 25mm.

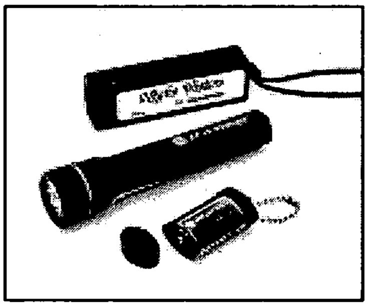
- **Plössl** - Plössl eyepieces have a 4-element lens designed for low-to-high power observing. The Plössls offer razor sharp views across the entire field, even at the edges! In the 1-1/4" barrel diameter, they are available in th following focal lengths: 6.3mm, 7.5mm, 10mm, 12.5mm, 17mm, 20mm, 26mm, 32mm and 40mm.

- **Ultima** - Ultima is not really a design, but a trade name for our 5-element, wide field eyepieces. In the 1-1/4" barrel diameter, they are available in th following focal lengths: 5mm, 7.5mm, 12.5mm, 18mm, 24mm, 30mm, 35mm, and 42mm. These eyepieces are all parfocal. The 35mm Ultima gives the widest possible field of view with a 1-1/4" diagonal and is idea for the NexStar with or without the Reducer/Corrector.



- **Lanthanum Eyepieces (LV Series)** - Lanthanum is a unique rare earth glas used in one of the field lenses of this new eyepiece. The Lanthanum glass reduces aberrations to a minimum. All are fully multicoated and have a astounding 20mm of eye relief — perfect for eyeglass wearers! In the 1-1/4" barrel diameter, they are available in the following focal lengths: 2.5mm, 4mm, 5mm, 6mm, 9mm, 10mm, 12mm and 15mm. Celestron also offers th LV Zoom eyepiece (#3777) with a focal length of 8mm to 24mm. It offers an apparent field of 40° at 24mm and 60° at 8mm. Eye relief ranges from 15mm to 19mm.

Eyepiece Filters - To enhance your visual observations of solar system objects, Celestron offers a wide range of colored filters that thread into the 1-1/4" oculars. Available individually are: #12 deep yellow, #21 orange, #25 red, #58 green, #80A light blue, #96 neutral density - 25%T, #96 neutral density - 13%T, and polarizing. These and other filters are also sold in sets.



Night Vision Flashlight - (#93588) - Celestron's premium model for astronomy, using two red LEDs to preserve night vision better than red filters or other devices. Brightness is adjustable. Operates on a single 9 volt battery (included).

Red Astro Lite – (#93590) – An economical squeeze-type flashlight fitted with a red cap to help preserve your night vision. Remove the red cap for normal flashlight operation. Very compact size and handy keychain.

Light Pollution Reduction (LPR) Filters - These filters are designed to enhance your views of deep sky astronomical objects when viewed from urban areas. LPR Filters selectively reduce the transmission of certain wavelengths of light, specifically those produced by artificial lights. This includes mercury and high and low pressure sodium vapor lights. In addition, they also block unwanted natural light (sky glow) caused by neutral oxygen emission in our atmosphere. Celestron offers a model for 1-1/4" eyepieces (#94126A) and a model that attaches to the rear cell ahead of the star diagonal and visual back (#94127A).

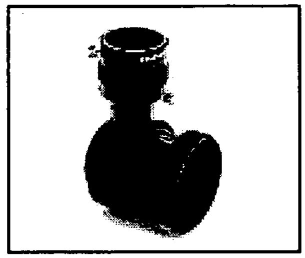
Micro Guide Eyepiece (#94171) - This multipurpose 12.5mm illuminated reticle can be used for guiding deep-sk astrophotos, measuring position angles, angular separations, and more. The laser etched reticle provides razor sharp lines and the variable brightness illuminator is completely cordless. The micro guide eyepiece produces 100 power when used with the NexStar at f/10.

Moon Filters (#94119-A) - Celestron's Moon Filters is an economical eyepiece filter for reducing the brightness of the moon and improving contrast, so greater detail can be observed on the lunar surface. The clear aperture is 21mm and the transmission is about 18%.

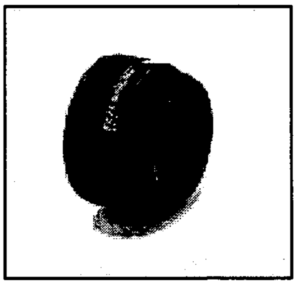
Planisphere (#93720) - A simple and inexpensive tool for all levels of observers, from naked eye viewers to users of highl sophisticated telescopes. The Celestron Planisphere makes it easy to locate stars for observing and is a great planet finder as well. A map of the night sky, oriented by month and day, rotates within a depiction of the 24 hours of the day, to display exactly which stars and planets will be visible at any given time. Ingeniously simple to use, yet quite effective. Made of durable materials and coated for added protection. Celestron Planispheres come in three different models, to match the latitude from which you're observing

For 20° to 40° of latitude	#93720-30
For 30° to 50° of latitude	#93720-40
For 40° to 60° of latitude	#93720-50

Polarizing Filter Set (#93608) - The polarizing filter set limits the transmission of light to a specific plane, thu increasing contrast between various objects. This is used primarily for terrestrial, lunar and planetary observing.



Radial Guider (#94176) - The Celestron® Radial Guider is specifically designed for use in prime focus, deep skystro photography and takes the place of the T-Adapter. This device allows you to photograph and guide simultaneously through the optical tube assembly of your telescope. This type of guiding produces the best results since what you see through the guiding eyepiece is exactly reproduced on the processed film. The Radial Guider is a "T"-shaped assembly that attaches to the rear cell of the telescope. As light from the telescope enters the guider, most passes straight through to the camera. A small portion, however, is diverted by a prism at an adjustable angle up to the guiding eyepiece. This guider has two features not found on other off-axis guiders; first, the prism and eyepiece housing rotate independently of the camera orientation making the acquisition of a guide star quite easy. Second, the prism angle is tunable allowing you to look at guide stars on-axis. This accessory works especially well with the Reducer/Corrector.



Reducer/Corrector (#94175) - This lens reduces the focal length of the telescopeb 37%, making your NexStar a 787.5mm f/6.3 instrument. In addition, this unique lens also corrects inherent aberrations to produce crisp images all the way across the field when used visually. When used photographically, there is some vignetting that produces a 26mm circular image on the processed film. It also increases the field of view significantly and is ideal for wide-field, deep-space viewing. It is also perfect for beginning prime focus, long-exposure astro photography when used with the radial guider. It makes guiding easier and exposures much shorter.

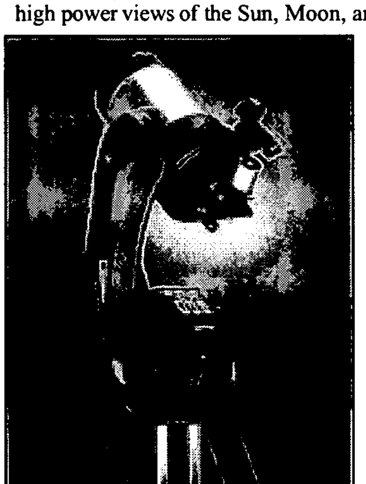
Sky Maps (#93722) - Celestron Sky Maps are the ideal teaching guide for learning the night sky. You wouldn't set off on a road trip without a road map, and you don't need to try to navigate the night sky without a map either. Even if you already know your way around the major constellations, these maps can help you locate all kinds of fascinating objects.

Skylight Filter (#93621) - The Skylight Filter is used on the Celestron NexStar telescope as a dust seal. The filter threads onto the rear cell of your telescope. All other accessories, both visual and photographic (with the exception of Barlow lenses), thread onto the skylight filter. The light loss caused by this filter is minimal.

T-Adapter (#93633-A) - T-Adapter (with additional T-Ring) allows you to attach your SLR camera to the rear cell of your Celestron NexStar. This turns your NexStar into a 1250mm telephoto lens perfect for terrestrial photography and short exposure lunar and filtered solar photography.

T-Ring - The T-Ring couples your 35mm SLR camera body to the T-Adapter, radial guider, or tele-extender. This accessory is mandatory if you want to do photography through the telescope. Each camera make (i.e., Minolta, Nikon, Pentax, etc.) has its own unique mount and therefore, its own T-Ring. Celestron has 8 different models for 35mm cameras.

Tele-Extender, Deluxe (#93643) - The tele-extender is a hollow tube that allows you to attach a camera to the telescope when the eyepiece is installed. This accessory is used for eyepiece projection photography which allows you to capture ver high power views of the Sun, Moon, and planets on film. The tele-extender fits over the eyepiece onto the visual back. This tele-extender works with eyepieces that have large housings, like the Celestron Ultima series.



NexStar shown on NexStar tripod

Tripod, NexStar - A stable tripod is a must for serious astronomical observing and photography. The lightweight field tripod (#93593) weighs less than 10 pounds and folds down to a compact 6"x36". It has a center brace and is perfectly sized for the NexStar. It come with the accessory tray tripod for added stabilit .

Vibration Suppression Pads (#93503) - These pads rest between the ground and tripod feet of your telescope. They reduce the amplitude and vibration time of your telescope when shaken by the wind or an accidental bump. This accessory is a must for long exposure prime focus photography.

Wedge, NexStar – The wedge allows you to tilt the telescope so that its polar axis is parallel to the earth's axis of rotation. Ideal for using your NexSta for guided astro photography.

A full description of all Celestron accessories can be found in the Celestron Accessory Catalog (#93685).

Appendix A - Technical Specifications

Optical Specification

Design	Schmidt-Cassegrain Catadioptric
Aperture	5 inches (127mm)
Focal Length	50 inches (1250mm)
F/ratio of the Optical System	10
Primary Mirror: Material Coatings	Fine Annealed Pyrex Starbright Coatings - 5 step multilayer process
Secondary Mirror: Material Coatings	Hand Figured Fine Annealed Pyrex Starbright Coatings - 5 step multilayer process
Central Obstruction	2" (16% by area)
Corrector Plate: Material Coatings	Optical Quality Glass A-R Coatings both sides
Highest Useful Magnification	300x (~ 4mm eyepiece)
Lowest Useful Magnification (7mm exit pupil)	23x (~ 54mm eyepiece) (~ 34mm eyepiece with optional Reducer/Corrector)
Resolution: Rayleigh Criterion Dawes Limit	1.09 arc seconds .91 arc seconds
Photographic Resolution	182 lines/mm
Light Gathering Power	330x unaided eye
Near Focus standard eyepiece or camera	~ 20 feet
Field of View: Standard Eyepiece : 35mm Camera	1.04° 1.6° x 1.1° (2.5° x 1.75°) - with optional Reducer/Corrector)
Linear Field of View (at 1000 yds)	55 feet
Magnification: Standard Eyepiece : Camera	50x 25x
Optical Tube Length	11 inches
Weight of Telescope	17.6 Lbs.

Electronic Specifications

Input Voltage Maximum Minimum	12 V DC Nominal 18 V DC Max. 8 V DC Min.
Batteries Required	8 AA Alkaline
Power Supply Requirements	12 VDC-750 mA (Tip positive)

Mechanical Specifications

Motor: Type Resolution	DC Servo motors with encoders, both axes .26 arc sec
Slew speeds	Nine slew speeds: 6.5° /sec, 3° /sec, 1.5°/sec, 128x, 64x, 16x, 8x, 2x, 1x
Hand Control	Double line, 16 character Liquid Crystal Display 19 fiber optic backlit LED buttons
Fork Arm	Cast aluminum, with integrated hand control receptacle

Software Specifications

Software Precision	16 bit, 20 arc sec. calculations
Ports	RS-232 communication port on hand control
Tracking Rates	Sidereal, Solar, Lunar and King
Tracking Modes	Alt-Az, EQ North & EQ South
Alignment Procedures	2-Star Alignment, AutoAlign
Database	25 user defined programmable object. Enhanced information on over 100 objects
Complete Revised NGC Catalog	7,840
Complete Messier Catalog	110
Complete Caldwell	109
Solar System objects	9
Famous Asterisms	20
Selected SAO Star	10,385
Total Object Database	**18,473**

Appendix B - Glossary of Terms

A-	
Absolute magnitude	The apparent magnitude that a star would have if it were observed from a standard distance of 10 parsecs, or 32.6 light-years. The absolute magnitude of the Sun is 4.8. at a distance of 10 parsecs, it would just be visible on Earth on a clear moonless night away from surface light.
Airy disk	The apparent size of a star's disk produced even by a perfect optical system. Since the star can never be focused perfectly, 84 per cent of the light will concentrate into a single disk, and 16 per cent into a system of surrounding rings.
Alt-Azimuth Mounting	A telescope mounting using two independent rotation axis allowing movement of the instrument in Altitude and Azimuth.
Altitude	In astronomy, the altitude of a celestial object is its Angular Distance above or below the celestial horizon.
Aperture	the diameter of a telescope's primary lens or mirror; the larger the aperture, the greater the telescope's light-gathering power.
Apparent Magnitude	A measure of the relative brightness of a star or other celestial object as perceived by an observer on Earth.
Arcminute	A unit of angular size equal to 1/60 of a degree.
Arcsecond	A unit of angular size equal to 1/3,600 of a degree (or 1/60 of an arcminute).
Asterism	A small unofficial grouping of stars in the night sky.
Asteroid	A small, rocky body that orbits a star.
Astrology	The pseudoscientific belief that the positions of stars and planets exert an influence on human affairs; astrology has nothing in common with astronom
Astronomical unit (AU)	The distance between the Earth and the Sun. It is equal to 149,597,900 km., usually rounded off to 150,000,000 km.
Aurora	The emission of light when charged particles from the solar wind slams into and excites atoms and molecules in a planet's upper atmosphere.
Azimuth	The angular distance of an object eastwards along the horizon, measured from due north, between the astronomical meridian (the vertical line passing through the center of the sky and the north and south points on the horizon) and the vertical line containing the celestial body whose position is to be measured..
B -	
Binary Stars	Binary (Double) stars are pairs of stars that, because of their mutual gravitational attraction, orbit around a common Center of Mass. If a group of three or more stars revolve around one another, it is called a multiple system. It is believed that approximately 50 percent of all stars belong to binary or multiple systems. Systems with individual components that can be seen separately by a telescope are called visual binaries or visual multiples. The nearest "star" to our solar system, Alpha Centauri, is actually our nearest example of a multiple star system, it consists of three stars, two very similar to our Sun and one dim, small, red star orbiting around one another.
C -	
Celestial Equator	The projection of the Earth's equator on to the celestial sphere. It divides the sky into two equal hemispheres.
Celestial pole	The imaginary projection of Earth's rotational axis north or south pole onto the celestial sphere.
Celestial Sphere	An imaginary sphere surrounding the Earth, concentric with the Earth's center.
Collimation	The act of putting a telescope's optics into perfect alignment.
D -	
Declination (DEC)	The angular distance of a celestial body north or south of the celestial equator. It may be said to correspond to latitude on the surface of the Earth.
E -	
Ecliptic	The projection of the Earth's orbit on to the celestial sphere. It may also be defined as "the apparent yearly path of the Sun against the stars".
Equatorial mount	A telescope mounting in which the instrument is set upon an axis which is parallel to the axis of the Earth; the angle of the axis must be equal to the observer's latitude.

F -

Focal length	The distance between a lens (or mirror) and the point at which the image of an object at infinity is brought to focus. The focal length divided by the aperture of the mirror or lens is termed the focal ratio.

J -

Jovian Planets	Any of the four gas giant planets that are at a greater distance form the sun than the terrestrial planets.

K -

Kuiper Belt	A region beyond the orbit of Neptune extending to about 1000 AU which is a source of many short period comets.

L -

Light-Year (ly)	A light-year is the distance light traverses in a vacuum in one year at the speed of 299,792 km/ sec. With 31,557,600 seconds in a year, the light-year equals a distance of 9.46 X 1 trillion km (5.87 X 1 trillion mi).

M -

Magnitude	Magnitude is a measure of the brightness of a celestial body. The brightest stars are assigned magnitude 1 and those increasingly fainter from 2 down to magnitude 5. The faintest star that can be seen without a telescope is about magnitude 6. Each magnitude step corresponds to a ratio of 2.5 in brightness. Thus a star of magnitude 1 is 2.5 times brighter than a star of magnitude 2, and 100 times brighter than a magnitude 5 star. The brightest star, Sirius, has an apparent magnitude of -1.6, the full moon is -12.7, and the Sun's brightness, expressed on a magnitude scale, is -26.78. The zero point of the apparent magnitude scale is arbitrary.
Meridian	A reference line in the sky that starts at the North celestial pole and ends at the South celestial pole and passes through the zenith. If you are facing South, the meridian starts from your Southern horizon and passes directly overhead to the North celestial pole.
Messier	A French astronomer in the late 1700's who was primarily looking for comets. Comets are haz diffuse objects and so Messier cataloged objects that were not comets to help his search. This catalog became the Messier Catalog, M1 through M110.

N -

Nebula	Interstellar cloud of gas and dust. Also refers to any celestial object that has a cloudy appearance.
North Celestial Pole	The point in the Northern hemisphere around which all the stars appear to rotate. This is caused b the fact that the Earth is rotating on an axis that passes through the North and South celestial poles. The star Polaris lies less than a degree from this point and is therefore referred to as the "Pole Star".
Nova	Although Latin for "new" it denotes a star that suddenly becomes explosively bright at the end of its life cycle.

O -

Open Cluster	One of the groupings of stars that are concentrated along the plane of the Milky Way. Most have an asymmetrical appearance and are loosely assembled. They contain from a dozen to many hundreds of stars.

P -

Parallax	Parallax is the difference in the apparent position of an object against a background when viewed b an observer from two different locations. These positions and the actual position of the object form a triangle from which the apex angle (the parallax) and the distance of the object can be determined i the length of the baseline between the observing positions is known and the angular direction of the object from each position at the ends of the baseline has been measured. The traditional method in astronomy of determining the distance to a celestial object is to measure its parallax.
Parfocal	Refers to a group of eyepieces that all require the same distance from the focal plane of the telescope to be in focus. This means when you focus one parfocal eyepiece all the other parfocal eyepieces, in a particular line of eyepieces, will be in focus.
Parsec	The distance at which a star would show parallax of one second of arc. It is equal to 3.26 light-years, 206,265 astronomical units, or 30,8000,000,000,000 km. (Apart from the Sun, no star lies within one parsec of us.)
Point Source	An object which cannot be resolved into an image because it to too far away or too small is considered a point source. A planet is far away but it can be resolved as a disk. Most stars cannot be resolved as disks, they are too far away.

R -

Reflector	A telescope in which the light is collected by means of a mirror.

Resolution	The minimum detectable angle an optical system can detect. Because of diffraction, there is a limit to the minimum angle, resolution. The larger the aperture, the better the resolution.
Right Ascension: (RA	The angular distance of a celestial object measured in hours, minutes, and seconds along the Celestial Equator eastward from the Vernal Equinox.
S -	
Schmidt Telescope	Rated the most important advance in optics in 200 years, the Schmidt telescope combines the best features of the refractor and reflector for photographic purposes. It was invented in 1930 b Bernhard Voldemar Schmidt (1879-1935).
Sidereal Rate	This is the angular speed at which the Earth is rotating. Telescope tracking motors drive the telescope at this rate. The rate is 15 arc seconds per second or 15 degrees per hour.
T -	
Terminator	The boundary line between the light and dark portion of the moon or a planet.
U -	
Universe	The totality of astronomical things, events, relations and energies capable of being described objectively.
V -	
Variable Star	A star whose brightness varies over time due to either inherent properties of the star or something eclipsing or obscuring the brightness of the star.
W -	
Waning Moon	The period of the moon's cycle between full and new, when its illuminated portion is decreasing.
Waxing Moon	The period of the moon's cycle between new and full, when its illuminated portion is increasing.
Z -	
Zenith	The point on the Celestial Sphere directly above the observer.
Zodiac	The zodiac is the portion of the Celestial Sphere that lies within 8 degrees on either side of the Ecliptic. The apparent paths of the Sun, the Moon, and the planets, with the exception of some portions of the path of Pluto, lie within this band. Twelve divisions, or signs, each 30 degrees in width, comprise the zodiac. These signs coincided with the zodiacal constellations about 2,000 years ago. Because of the Precession of the Earth's axis, the Vernal Equinox has moved westward b about 30 degrees since that time; the signs have moved with it and thus no longer coincide with the constellations.

APPENDIX C
LONGITUDES AND LATITUDES

	LONGITUDE degrees	min	LATITUDE degrees	min
ALABAMA				
Anniston	85	51	33	34.8
Auburn	85	26.4	32	40.2
Birmingha	86	45	33	34.2
Centreville	87	15	32	54
Dothan	85	27	31	19.2
Fort Rucker	85	43.2	31	16.8
Gadsden	86	5.4	33	58.2
Huntsville	86	46.2	34	39
Maxwell AFB	86	22.2	32	22.8
Mobile	88	15	30	40.8
Mobile Aeros	88	4.2	30	37.8
Montgomery	86	2.4	32	18
Muscle Shoal	87	37.2	34	45
Selma	86	59.4	32	20.4
Troy	86	1.2	31	52.2
Tuscaloosa	87	37.2	33	13.8
ALASKA				
Anchorage	149	51	61	13.2
Barrow	156	46.8	71	18
Fairbanks	147	52.2	64	49.2
Haines Hrbor	135	25.8	59	13.8
Homer	151	3	59	37.8
Juneau	134	34.8	58	22.2
Ketchikan	131	4.2	55	21
Kodiak	152	3	57	45
Nome	165	25.8	64	30
Sitka	135	21	57	4.2
Sitkinak	154	1.2	56	52.8
Skagway	135	31.8	59	45
Valdez	146	21	61	7.8
ARIZONA				
Davis-M AFB	110	52.8	32	10.2
Deer Valley	112	4.8	33	40.8
Douglas	109	3.6	31	27
Falcon Fld	111	43.8	33	28.2
Flagstaff	111	40.2	35	7.8
Fort Huachuc	110	21	31	36
Gila Bend	113	10.2	33	33
Goodyear	112	22.8	33	25.2
GrandCanyon	112	9	35	57
Kingman	113	57	35	16.2
Luke	112	22.8	33	31.8
Page	111	27	36	55.8
Payson	111	19.8	34	13.8
Phoeni	112	1.2	33	25.8
Prescott	112	25.8	34	39
Safford Awrs	109	40.8	32	49.2
Scottsdale	111	55.2	33	37.2
Show Low	110	0	34	16.2
Tucson	110	55.8	32	7.2
Williams AFB	111	40.2	33	18
Winslow	110	43.8	35	1.2
Yuma	115	0	33	6
Yuma Mcas	114	37.2	32	39
Yuma Prv Gd	114	2.4	32	51
ARKANSAS				
Blytheville	89	57	35	58.2
Camden	92	2.4	33	31.2
El Dorado	92	4.8	33	13.2
Fayetteville	94	10.2	36	0
Ft Smith	94	22.2	35	19.8
Harrison	93	9	36	16.2
Hot Springs	93	0.6	34	28.8
Jonesboro	90	39	35	49.8
Little Rock	92	22.8	35	13.2
Pine Bluff	91	55.8	34	10.2
Springdale	94	7.8	36	10.8
Texarkana	94	0	33	27
Walnut Ridge	90	55.8	36	7.8
CALIFORNIA				
Alameda	122	19.2	37	46.8
Alturas	120	31.8	41	28.8
Arcata	124	0.6	40	58.8
Bakersfield	119	3	35	25.8
Beale AFB	121	27	39	7.8
Beaumont	116	57	33	55.8
Bicycle Lk	116	37.2	35	16.8
Big Bear	116	40.8	34	16.2
Bishop	118	3.6	37	36
Blue Canyon	120	4.2	39	16.8

	LONGITUDE degrees	min	LATITUDE degrees	min
Blythe	114	43.2	33	37.2
Burbank	118	22.2	34	12
Campo	116	28.2	32	37.2
Carlsbad	117	16.8	33	7.8
Castle AFB	120	34.2	37	22.8
Chico	121	51	39	46.8
China Lake	117	40.8	35	40.8
Chino	117	37.8	33	58.2
Concord	122	3	37	58.8
Crescent Cty	124	13.8	41	46.8
Daggett	116	46.8	34	52.2
Edwards AFB	117	52.8	34	54
El Centro	115	40.8	32	49.2
El Monte	118	1.8	34	4.8
El Toro	117	43.8	33	40.2
Eureka	124	16.8	41	19.8
Fort Hunter	121	19.2	36	0
Fort Ord	121	46.2	36	40.8
Fresno	119	43.2	36	46.2
Fullerton	117	58.2	33	52.2
George AFB	117	22.8	34	34.8
Hawthorne	118	19.8	33	55.2
Hayward	122	7.2	37	39
Imperial	115	34.2	32	49.8
Imperial Bch	117	7.2	32	34.2
La Verne	117	46.8	34	6
Lake Tahoe	120	0	38	54
Lancaster	118	13.2	34	43.8
Livermore	121	49.2	37	42
Long Beach	118	9	33	49.2
Los Alamitos	118	3	33	46.8
Los Angeles	118	2.4	33	55.8
Mammoth	118	55.2	37	37.8
March AFB	117	16.2	33	52.8
Marysville	121	34.2	39	6
Mather AFB	121	1.8	38	34.2
Mcclellan	121	2.4	38	40.2
Merced	120	31.2	37	16.8
Miramar NAS	117	9	32	52.2
Modesto	120	57	37	37.8
Moffet	122	3	37	25.2
Mojave	118	9	35	3
Montague	122	31.8	41	43.8
Monterey	121	51	36	34.8
Mount Shasta	122	19.2	41	19.2
Mount Wilson	118	4.2	34	13.8
Napa	122	16.8	38	13.2
Needles	114	37.2	34	46.2
North Is	117	1.2	32	42
Norton AFB	117	13.8	34	6
Oakland	122	13.2	37	43.8
Ontario Intl	117	37.2	34	3
Oxnard	119	1.2	34	12
Palm Springs	116	3	33	49.8
Palmdale	118	7.8	35	3
Palo Alto	122	7.2	37	28.2
Paso Robles	120	37.8	35	40.2
Pillaro Pt	122	49.8	37	49.8
Point Mugu	119	7.2	34	7.2
Pt Arena	124	13.2	39	34.8
Pt Arguello	121	7.2	34	57
Pt Piedras	121	16.8	35	40.2
Red Bluff	122	15	40	9
Redding	122	1.8	40	30
Riverside	117	27	33	57
Sacramento	121	3	38	31.2
Salinas	121	3.6	36	40.2
San Carlos	122	15	37	31.2
San Clemente	117	37.2	33	25.2
San Diego	117	7.8	32	49.2
San Francisco	122	22.8	37	37.2
San Jose	121	55.2	37	22.2
San Luis Obi	120	39	35	13.8
San Mateo	117	34.8	33	22.8
San Miguel	120	2.4	34	1.8
Sandburg	118	43.8	34	45
Santa Ana	117	52.8	33	40.2
Santa Barb	119	49.8	34	25.8
Santa Maria	120	27	34	54
Santa Monica	118	27	34	1.2
Santa Rosa	122	49.2	38	31.2

	LONGITUDE degrees	min	LATITUDE degrees	min
Shelter Cove	124	4.2	40	1.8
Siskiyou	122	28.2	41	46.8
Stockton	121	15	37	54
Superior Val	117	0.6	35	19.8
Susanville	120	57	40	37.8
Thermal	116	10.2	33	37.8
Torrance	118	19.8	33	48
Travis AFB	121	55.8	38	16.2
Tahoe	120	7.8	39	19.2
Tustin Mcas	117	49.8	33	42
Ukiah	123	1.2	39	7.8
Van Nuys	118	28.8	34	13.2
Vandenberg	120	57	35	12
Visalia	119	2.4	36	19.2
COLORADO				
Air Force A	105	21	39	31.2
Akron	103	13.2	40	10.2
Alamosa	105	52.2	37	27
Aspen	106	52.2	39	13.2
Brmfield/Jef	105	7.2	39	54
Buckley	104	45	39	43.2
Colo Sprgs	104	43.2	38	49.2
Cortez	108	37.8	37	18
Craig-Moffat	107	31.8	40	30
Denver	104	52.2	39	45
Durango	107	45	37	9
Eagle	106	55.2	39	39
Englewood	104	49.8	39	34.2
Fort Carson	104	46.2	38	40.8
Fraser	105	3	39	34.2
Ft Col/Lovel	105	1.2	40	27
Ft Collins	105	4.8	40	34.8
Grand Jct	108	31.8	39	7.2
Greeley-Wld	104	37.8	40	25.8
Gunnison	106	55.8	38	33
La Junta	103	31.2	38	3
Lamar	102	3.6	38	7.2
Leadville	106	1.8	39	15
Limon	103	4.2	39	10.8
Montrose	107	52.8	38	30
Pueblo	104	31.2	38	16.8
Rifle	107	4.8	39	31.8
Salida	106	3	38	31.8
Trinidad	104	19.8	37	15
Winter Park	105	52.2	40	0
CONNECTICU				
Bridgeport	73	7.8	41	10.2
Danbury	73	28.8	41	22.2
Groton	72	3	41	19.8
Hartford	72	39	41	43.8
New Haven	72	40.2	41	13.2
New London	72	4.8	41	18
Windsor Loc	72	40.8	41	55.8
DELAWARE				
Dover	75	28.2	39	7.8
Wilmington	75	3.6	39	40.2
D.C./WASH				
Washington	77	27.6	38	57
FLORIDA				
Apalachicola	85	1.8	29	43.8
Astor NAS	81	34.2	29	7.2
Avon Park G	81	33	28	4.8
Cape Canaveral	80	33	28	28.2
Cecil	81	52.8	30	13.2
Crestview	86	31.2	30	46.8
Cross City	83	0.6	29	37.2
Daytona Bch	81	3	29	10.8
Duke Fld	86	31.2	30	39
Eglin AFB	86	31.8	30	28.8
Egmont Key	82	46.2	27	36
Fort Myers	81	52.2	26	34.8
Ft Lauderdale	80	9	26	4.2
Ft Myers	81	52.2	26	39
Gainesville	82	16.2	29	40.8
Homestead	80	22.8	25	28.8
Hurlburt Fld	86	40.8	30	25.8
Jacksonville	81	40.8	30	13.8
Key West	81	45	24	33
Lakeland	81	57	28	1.8
Macdill AFB	82	31.2	27	51
Marianna	85	10.8	30	50.4
Mayport NAS	81	25.2	30	24

	LONGITUDE		LATITUDE	
	degrees	min	degrees	min
Melbourne	80	37.8	28	6
Miami	80	16.8	25	49.2
Naples	81	4.8	26	7.8
Nasa Shuttle	80	40.8	28	37.2
Orlando	81	19.2	28	25.8
Panama City	85	40.8	30	12
Patrick AFB	80	3.6	28	13.8
Pensacola	87	19.2	30	21
Ruskin	82	3.6	27	58.2
Saint Peters	82	40.8	27	55.2
Sanford	81	15	28	46.8
Sarasota	82	33	27	24
Tallahassee	84	22.2	30	22.8
Tampa Intl	82	31.8	27	58.2
Titusville	80	4.8	28	31.2
Tyndall AFB	85	34.8	30	4.2
Vero Beach	80	25.2	27	39
West Palm Beach	80	7.2	26	40.8
Whiting Fld	87	1.2	30	43.2
GEORGIA				
Albany	84	10.8	31	31.8
Alma	82	31.2	31	31.8
Athens	83	19.2	33	57
Atlanta	84	25.2	33	39
Augusta/Bush	81	58.2	33	22.2
Brunswick	81	22.8	31	9
Columbus	84	55.8	32	31.2
Dobbins AFB	84	31.2	33	55.2
Fort Benning	85	0	32	19.8
Ft Stewart	81	34.2	31	52.8
Hunter Aaf	81	9	32	1.2
La Grange	85	4.2	33	0.6
Macon/Lewis	83	39	32	42
Moody AFB	83	1.2	30	58.2
Robins AFB	83	3.6	32	37.8
Rome/Russell	85	10.2	34	21
Valdosta	83	16.8	30	46.8
Waycross	82	2.4	31	15
HAWAII				
Barbers Pt	158	7.2	21	31.8
Barking San	160	1.8	22	3
Fr Frigate	166	28.2	24	27
Hilo	155	4.2	19	43.2
Honolulu Int	157	55.8	21	21
Kahului Maui	156	25.8	20	54
Kaneohe Mca	158	16.8	21	45
Kilauea Pt	159	40.2	22	22.8
Lanai-Lanai	156	57	20	48
Lihue-Kauai	159	21	21	58.8
Maui	156	49.8	20	58.2
Molokai	157	0.6	21	9
Upolo Pt Ln	156	28.2	20	25.2
Waimea-Koha	156	7.2	20	0
IDAHO				
Boise	116	13.2	43	34.2
Burley	113	46.2	42	31.8
Challis	114	13.2	44	31.2
Coeur d'Alene	116	49.2	47	46.2
Elk City	115	25.8	45	49.2
Gooding	115	10.2	43	0
Grangeville	116	7.8	45	55.2
Idaho Falls	112	4.2	43	31.2
Lewiston	117	1.2	46	22.8
Malad City	112	19.2	42	10.2
Malta	113	22.2	42	18
Mccall	116	0.6	44	52.8
Mullan	115	4.8	47	28.2
Pocatello	112	3.6	42	55.2
Salmon	113	5.4	45	10.8
Soda Springs	111	34.8	42	39
Sun Valley	114	1.8	43	30
Twin Falls	114	28.8	42	28.8
ILLINOIS				
Alton	90	3	38	52.8
Aurora	88	19.2	41	46.2
Bistate Park	90	9	38	34.2
Bloomington	88	55.8	40	28.8
Bradford	89	3.6	41	9.6
Cairo	89	13.2	37	4.2
Carbondale	89	15	37	46.8
Centralia	89	5.4	38	30.6
Champaign	88	16.8	40	1.8
Chicago	87	39	41	54
Danville	87	3.6	40	12
DeKalb	88	43.2	41	55.8
Decatur	88	52.2	39	49.8
Du Page	88	15	41	55.2
Galesburg	90	25.8	40	55.8

	LONGITUDE		LATITUDE	
	degrees	min	degrees	min
Glenview NAS	87	49.2	42	4.8
Kankakee	87	51	41	4.2
Macomb	90	39.6	40	31.2
Marion	89	0	37	45
Marseilles	88	40.8	41	22.2
Mattoon	88	16.8	39	28.8
Moline/Quad	90	31.2	41	27
Mount Vernon	88	51.6	38	19.2
Peoria	89	40.8	40	40.2
Quincy	91	1.2	39	55.8
Rockford	89	0.6	42	12
Salem	88	57.6	38	37.8
Scott AFB	89	51	38	33
Springfield	89	40.2	39	51
Sterling	89	40.2	41	44.4
Taylorville	89	19.8	39	31.8
Vandalia	89	10.2	38	59.4
INDIANA				
Bakalar	86	3	39	22.8
Bloomington	86	37.2	39	7.8
Elkhart	86	0	41	43.2
Evansville	87	31.8	38	3
Fort Wayne	85	1.2	41	0
Gary	87	25.2	41	37.2
Grissom AFB	86	9	40	39
Indianapolis	86	16.2	39	43.8
Muncie	85	22.8	40	13.8
South Bend	86	19.2	41	42
Terre Haute	87	1.8	39	27
W Lafayette	86	55.8	40	25.2
IOWA				
Burlington	91	7.2	40	46.8
Cedar Rapids	91	4.2	41	52.8
Des Moines	93	39	41	31.8
Dubuque	90	4.2	42	24
Estherville	94	45	43	24
Fort Dodge	94	10.8	42	33
Lamoni	93	55.8	40	37.2
Mason City	93	19.8	43	9
Ottumwa	92	27	41	6
Sioux City	96	22.8	42	24
Spencer	95	9	43	10.2
Waterloo Mun	92	2.4	42	33
KANSAS				
Chanute	95	28.8	37	40.2
Col. J Jabar	97	13.2	37	45
Concordia	97	39	39	33
Dodge City	99	58.2	37	46.2
Elkhart	101	52.8	37	0
Emporia	96	1.2	38	19.8
Ft Leavnwrth	94	55.2	39	22.2
Ft Riley	96	46.2	39	3
Garden City	100	43.2	37	55.8
Goodland	101	4.2	39	22.2
Hays	99	16.2	38	51
Hill City	99	49.8	39	22.8
Hutchinson	97	52.2	38	4.2
Johnson Cnty	94	52.8	38	49.2
Liberal	100	58.2	37	3
Manhatten	96	40.2	39	9
Mcconnell Af	97	16.2	37	37.2
Medicine Ldg	98	34.8	37	18
Olathe	94	5.4	38	51
Russell	98	49.2	38	52.2
Salina	97	39	38	48
Topeka	95	37.2	39	4.2
Topeka/Forbe	95	40.2	38	57
Wichita	97	25.8	37	39
KENTUCKY				
Bowling Gren	86	25.8	36	58.2
Ft Campbell	87	3	36	40.2
Ft Kno	85	58.2	37	54
Jackson	83	19.2	37	36
Lexington	85	0	38	3
London	84	4.2	37	4.8
Louisville	85	40.2	38	13.8
Owensboro	87	10.2	37	45
Paducah	88	46.2	37	4.2
Pikeville	82	31.2	37	28.8
LOUISIANA				
Alexandria	92	1.8	31	22.8
Barksdale	93	40.2	32	30
Baton Rouge	91	9	30	31.8
Boothville	89	40.2	29	33
Cameron Heli	93	1.8	29	46.8
Claiborne R	92	57	31	13.2
England AFB	92	33	31	19.8
Eugene Is.	91	46.8	28	28.2
Fort Polk	93	1.2	31	3

	LONGITUDE		LATITUDE	
	degrees	min	degrees	min
Grand Isle	90	4.2	29	10.8
High Island	94	2.4	28	7.8
Houma	90	39	29	34.2
Intercoastal	92	7.2	29	43.8
Lafayette	92	0	30	12
Lake Charles	93	13.2	30	7.2
Lk Palourde	91	0.6	29	42
Missippi Can	89	3	28	46.8
Monroe	92	3	32	31.2
Morgan City	91	1.2	29	42
New Iberia	91	52.8	30	1.8
New Orleans	90	15	29	58.8
S Marsh Isl	91	58.8	28	18
Shreveport	93	45	32	31.2
Slidel	89	49.2	30	21
MAINE				
Augusta	69	4.8	44	19.2
Bangor	68	49.2	44	48
Bar Harbor	68	22.2	44	27
Brunswick	69	55.8	43	52.8
Caribou Mun	68	1.2	46	52.2
Greenville	69	33	45	27
Houlton	67	46.8	46	7.8
Loring AFB	67	52.8	46	57
Portland	70	19.2	43	39
Presque Isle	68	3	46	40.8
Rockland	69	7.2	44	4.2
Rumford	70	52.8	44	52.8
MARYLAND				
Andrews AFB	76	52.2	38	49.2
Baltimore	76	40.2	39	10.8
Fort Meade	76	46.2	39	4.8
Hagerstown	77	43.2	39	42
Ocean City	75	7.8	38	33
Patuxent	76	2.4	38	16.8
Phillips	76	10.2	39	28.2
Salisbury	75	3	38	19.8
MASS-ACHUSETTS				
Bedford	71	16.8	42	28.2
Beverly	70	55.2	42	34.8
Boston	71	1.8	42	22.2
Cape Cod	70	3	41	46.8
Chatha	69	58.2	41	40.2
Fort Devens	71	3.6	42	34.2
Hyannis	70	16.8	41	40.2
Lawrence	71	7.2	42	43.2
Marthas Vine	70	37.2	41	24
Nantucket	70	4.2	41	15
New Bedford	70	58.2	41	40.8
Norwood	71	10.8	42	10.8
Otis ANGB	70	31.2	41	39
Pittsfield	73	10.8	42	15.6
S Weymouth	70	55.8	42	9
Westfield	72	43.2	42	10.2
Westover	72	31.8	42	12
Worcester	71	52.2	42	16.2
MICHIGAN				
Alpena	83	34.2	45	4.2
Ann Arbor	83	45	42	13.2
Battle Creek	85	13.8	42	18
Benton Harbor	86	25.8	42	7.8
Chippewa	84	28.2	46	15
Coopersville	85	57	43	4.2
Copper Harb	87	51	47	28.2
Detroit	83	1.2	42	25.2
Escanaba	87	4.8	45	43.8
Flint/Bishop	83	45	42	58.2
Grand Rapids	85	31.2	42	52.8
Hancock	88	3	47	10.2
Harbor Beach	82	31.8	43	49.8
Houghton Lake	84	40.8	44	22.2
Iron Mtn	88	7.2	45	49.2
Ironwood	90	7.8	46	31.8
Jackson	84	28.2	42	16.2
Kalamazoo	85	33	42	13.8
Lansing	84	3.6	42	46.2
Manistee	86	15	44	16.2
Marquette	87	57	46	52.8
Menominee	87	37.8	45	7.2
Muskegon	86	15	43	10.2
Pellston	84	4.8	45	34.2
Pontiac	83	25.2	42	40.2
Saginaw	84	4.8	43	31.8
Sault Ste M	84	22.2	46	28.2
Sawyer AFB	87	2.4	46	21
Selfridge	82	49.8	42	37.2
Seul Choi	85	55.2	45	55.2
Traverse Cty	85	34.8	44	43.8

	LONGITUDE		LATITUDE	
	degrees	min	degrees	min
Wurtsmith	83	2.4	44	27
Ypsilanti	83	31.8	42	13.8
MINNESOT				
Albert Lea	93	22.2	43	40.8
Alexandria	95	22.8	45	52.2
Bemidji Muni	94	55.8	47	30
Brainerd-Crw	94	7.8	46	24
Detroit Laks	95	52.8	46	49.2
Duluth	92	10.8	46	49.8
Ely	91	49.2	47	54
Fairmont	94	25.2	43	39
Fergus Falls	96	4.2	46	18
Grand Rapids	93	31.2	47	13.2
Hibbing	92	51	47	22.8
Intl Falls	93	22.8	48	34.2
Litchfield	94	31.2	45	7.8
Mankato	93	55.2	44	13.2
Marshall Arpt	95	49.2	44	27
Minneapolis	93	28.2	44	49.8
Park Rapids	95	4.2	46	54
Pequot Lake	94	19.2	46	36
Rochester	92	3	43	55.2
Saint Paul	93	3	44	55.8
St Cloud	94	4.2	45	33
Thief River	96	10.8	48	4.2
Tofte	90	49.8	47	34.8
Warroad	95	21	48	55.8
Worthington	95	34.8	43	39
MISSISSIPPI				
Columbus AFB	88	27	33	39
Golden Trian	88	34.8	33	27
Greenville	90	58.8	33	28.8
Greenwood	90	4.8	33	30
Gulfport	89	4.2	30	24
Hattiesburg	89	19.8	31	28.2
Jackson	90	4.8	32	19.2
Keesler AFB	88	55.2	30	25.2
Laurel	89	10.2	31	40.2
Mccomb	90	28.2	31	10.8
Meridian NAS	88	34.2	32	33
Meridian/Key	88	45	32	19.8
Natchez	91	15	31	37.2
Oxford	89	32.4	34	23.4
Tupelo	88	46.2	34	16.2
MISSOURI				
Columbia	92	13.2	38	49.2
Cape Girardeau	89	34.8	37	13.8
Ft Leonard	92	7.8	37	45
Jefferson City	92	10.2	38	36
Joplin	94	3	37	10.2
Kansas City	94	43.2	39	19.2
Kirksville	92	33	40	6
Monett	94	21	37	19.8
Muskogee	95	21.6	35	39.6
Poplar Bluff	90	28.2	36	46.2
Richards-Geb	94	33	38	51
Spickard	93	43.2	40	15
Springfield	93	22.8	37	13.8
St Joseph	95	31.8	40	16.8
St Louis	90	22.2	38	45
Vichy/Rolla	91	46.2	38	7.8
West Plains	92	25.2	37	13.2
Whiteman AFB	93	33	38	43.8
MONTANA				
Billings	108	31.8	45	48
Bozeman	111	9	45	46.8
Broadus	105	40.2	45	40.2
Butte	112	3	45	57
Cut Bank	112	22.2	48	36
Dillon	112	33	45	15
Drummond	113	9	46	40.2
Glasgow	106	37.2	48	13.2
Glendive	104	4.8	47	7.8
Great Falls	111	22.2	47	28.8
Harlowton	109	49.8	46	25.8
Havre	109	46.2	48	33
Helena	112	0	46	36
Jordan	106	55.8	47	19.8
Kalispell	114	16.2	48	18
Lewiston	109	27	47	3
Livingston	110	25.8	45	42
Malmstrom	111	10.8	47	30
Miles City	105	52.2	46	25.8
Missoula	114	4.8	46	55.2
Monida	112	19.2	44	34.2
Sidney	104	10.8	47	43.2
W Yellowston	111	0.6	44	39
NEBRASK				
Ainsworth	99	58.8	42	34.8
Alliance	102	4.8	42	3
Beatrice	96	45	40	19.2
Broken Bow	99	39	41	25.8
Burwell	99	9	41	46.8
Chadron	103	4.8	42	49.8
Columbus	97	21	41	27
Cozad	100	0	40	52.2
Falls City	95	34.8	40	4.2
Grand Island	98	19.2	40	58.2
Hastings	98	25.8	40	36
Imperial	101	23.4	40	19.8
Kearney	99	0	40	43.8
Lincoln Muni	96	45	40	51
Mccook	100	34.8	40	13.2
Mullen	101	3	42	3
Norfolk	97	25.8	41	58.8
North Omaha	96	1.2	41	22.2
North Platte	100	40.8	41	7.8
O'neill	98	40.8	42	28.2
Offutt AFB	95	55.2	41	7.2
Omaha	95	5.4	41	18
Ord/Sharp	98	57	41	37.2
Scottsbluff	103	3.6	41	52.2
Sidney Muni	102	58.8	41	6
Valentine	100	33	42	52.2
NEVAD				
Austin	117	7.8	39	49.8
Battle Mtn	116	52.2	40	37.2
Caliente	114	31.2	37	37.2
Elko	115	46.8	40	49.8
Ely/Yelland	114	51	39	16.8
Eureka	115	58.2	39	30
Fallon NAS	118	4.2	39	25.2
Hawthorne	118	37.8	38	33
Ind Sprng Rn	115	34.2	36	31.8
Las Vegas	115	10.2	36	4.8
Lovelock	118	55.2	40	6
Mercury	116	1.2	36	37.2
Nellis AFB	115	1.8	36	13.8
Owyhee	116	10.2	42	34.8
Reno	119	46.8	39	30
Tonopah	117	4.8	38	4.2
Wildhorse	116	15	41	19.8
Winnemucca	117	4.8	40	54
Yucca Flat	116	4.8	37	34.8
NEW HAMPSHIRE				
Berlin	71	10.8	44	34.8
Concord	71	3	43	12
Jaffrey	72	0	42	48
Keene	72	16.2	42	54
Laconia	71	25.8	43	34.2
Lebanon	72	1.8	43	37.8
Manchester	71	25.8	42	55.8
Mt Washingtn	71	1.8	44	16.2
Nashua	71	31.2	42	46.8
Pease AFB	70	49.2	43	4.8
Wolfeboro	71	22.8	44	0
NEW JERSEY				
Atlantic Cty	74	34.2	39	27
Barnegat Ls	74	16.8	40	16.8
Fairfield	74	16.8	40	52.2
Lakehurst	74	21	40	1.8
Mcguire AFB	74	3.6	40	1.2
Millville	75	4.2	39	22.2
Morristown	74	25.2	40	48
Newark Intl	74	10.2	40	42
Teterboro	74	3	40	51
Trenton	74	49.2	40	16.8
NEW MEXICO				
Albuquerque	106	3.6	35	3
Cannon	103	19.2	34	22.8
Carlsbad	104	16.2	32	19.8
Clayton Arpt	103	9	36	27
Corona	105	40.8	34	6
Deming	107	4.2	32	15
Farmington	108	13.8	36	45
Gallup/Clark	108	46.8	35	31.2
Grants	107	5.4	35	10.2
Hobbs	103	1.2	32	40.8
Holloman AFB	106	0.6	32	51
Las Cruces	106	46.2	32	18
Las Vegas	105	9	35	39
Los Alamos	106	16.8	35	52.8
Moriarity	106	3	34	58.8
Northrup Str	106	2.4	32	54
Raton	104	3	36	44.4
Roswell	104	31.8	33	18
Santa Fe	106	4.8	35	37.2
Silver City	108	10.2	32	37.8
Socorro	106	5.4	34	4.2
Taos	105	34.2	36	25.2
Truth Or Con	107	16.2	33	13.8
Tucumcari	103	3.6	35	10.8
White Sands	106	2.4	32	37.8
NEW YORK				
Albany	73	4.8	42	45
Ambrose	74	22.2	40	45
Binghamton	75	58.8	42	13.2
Buffalo	78	43.8	42	55.8
Dansville	78	1.2	42	58.2
Elmira	76	5.4	42	10.2
Farmingdale	73	25.8	40	43.8
Fort Drum	75	43.8	44	3
Glens Falls	73	37.2	43	21
Griffiss AFB	75	2.4	43	13.8
Islip	73	0.6	40	46.8
Ithaca	76	28.2	42	28.8
Jamestown	79	15	42	9
Massena	74	51	44	55.8
Monticello	74	4.8	41	42
New York	73	58.8	40	46.2
Newburgh	74	0.6	41	30
Niagara Fall	78	57	43	6
Ogdensburg	75	2.4	44	40.8
Oneonta	75	7.2	42	52.2
Plattsburgh	73	28.2	44	39
Rochester	77	40.2	43	7.2
Saranac Lk	74	1.2	44	22.8
Schenectady	73	55.8	42	51
Syracuse	76	7.2	43	7.2
Utica	75	22.8	43	9
Watertown	76	1.2	44	0
Westhampton	72	37.8	40	51
White Plains	73	43.2	41	4.2
NORTH CAROLINA				
Asheville	82	33	35	25.8
Cape Hattera	75	33	35	16.2
Charlotte	80	55.8	35	13.2
Cherry Point	76	52.8	34	54
Dare Co Gr	76	3	36	7.8
Diamond Sho	75	3	35	15
Elizabeth	76	10.8	36	16.2
Fayetteville	78	52.8	35	0
Fort Bragg	78	55.8	35	7.8
Greensboro	79	57	36	4.8
Hickory	81	22.8	35	45
Hot Springs	82	49.2	35	54
Jacksonville	77	37.2	34	49.2
Kinston	77	37.8	35	19.2
Mackall Aaf	79	3	35	1.8
Manteo Arpt	75	40.8	35	55.2
New Bern	77	3	35	4.8
New River	77	25.8	34	42
Pope AFB	79	1.2	35	10.2
Raleigh-Durh	78	46.8	35	52.2
Rocky Mt	77	52.8	35	51
Southern Pin	79	23.4	35	14.4
Wilmington	77	55.2	34	16.2
Winston-Salem	80	13.8	36	7.8
NORTH DAKOTA				
Bismarck	100	45	46	46.2
Devil's Lake	98	5.4	48	7.2
Dickenson	102	4.8	46	46.8
Fargo	96	4.8	46	54
Grand Forks	97	10.8	47	57
Jamestown	98	40.8	46	55.2
Lidgerwood	97	9	46	6
Minot	101	16.8	48	16.2
Roseglen	101	49.8	47	45
Williston	103	37.8	48	10.8
OHIO				
Athens	82	13.8	39	12.6
Canton	81	25.8	40	55.2
Cincinnati	84	40.2	39	3
Cleveland	81	40.8	41	31.2
Columbus	82	52.8	40	0
Dayton	84	1.2	39	54
Findlay	83	40.2	41	1.2
Mansfield	82	31.2	40	49.2
Rickenbacker	82	55.8	39	49.2
Toledo	83	4.8	41	36
Willoughby	81	2.4	41	37.8
Youngstown	80	40.2	41	16.2
Zanesville	81	5.4	39	57

	LONGITUDE degrees	min	LATITUDE degrees	min
OKLAHOMA				
Altus AFB	99	16.2	34	40.2
Ardmore	97	1.2	34	18
Bartlesville	96	0	36	45
Clinton	99	1.2	35	21
Enid	97	4.8	36	22.8
Fort Sill	98	2.4	34	39
Gage	99	46.2	36	18
Hobart	99	3	35	0
Lawton	98	25.2	34	34.2
Mcalester	95	46.8	34	52.8
Norman	97	28.2	35	13.8
Oklahoma	97	3.6	35	24
Page	94	37.2	34	40.8
Ponca City	97	0.6	36	43.8
Stillwater	97	5.4	36	9.6
Tinker AFB	97	22.8	35	25.2
Tulsa	95	5.4	36	12
Vance AFB	97	55.2	36	19.8
OREGON				
Astoria	123	52.8	46	9
Aurora	122	45	45	15
Baker	117	49.2	44	49.8
Brookings	124	28.2	42	4.8
Burns Arpt	118	57	43	36
Cape Blanco	124	57	43	22.8
Cascade	121	52.8	45	40.8
Corvallis	123	16.8	44	30
Eugene	123	13.2	44	7.2
Hillsboro	122	57	45	31.8
Klamath Fall	121	43.8	42	9
La Grande	118	0	45	16.8
Lake View	120	21	42	10.8
Meacha	118	2.4	45	30
Medford	122	52.2	42	22.2
Newport	124	3	44	37.8
North Bend	124	15	43	25.2
Ontario	117	1.2	44	1.2
Pendleton	118	51	45	40.8
Portland	122	3.6	45	36
Redmond	121	9	44	16.2
Roseburg	123	22.2	43	13.8
Salem	123	0	44	55.2
Sexton	123	22.2	42	37.2
The Dalles	121	9	45	37.2
Troutdale	122	2.4	45	33
PENN-SYLVANIA				
Allentown	75	25.8	40	39
Altoona	78	19.2	40	18
Beaver Falls	80	19.8	40	45
Blairsville	79	5.4	40	16.2
Bradford	78	37.8	41	48
Dubois	78	5.4	41	10.8
Erie	80	10.8	42	4.8
Franklin	79	52.2	41	22.8
Harrisburg	76	51	40	13.2
Johnstown	78	49.8	40	19.2
Lancaster	76	1.8	40	7.8
Latrobe	79	2.4	40	16.8
Middletown	76	46.2	40	12
Muir	76	34.2	40	25.8
Nth Philadel	75	1.2	40	4.8
Philadelphia	75	15	39	52.8
Philipsburg	78	7.8	41	28.2
Pittsburgh	79	55.8	40	21
Reading	75	58.2	40	22.8
Site R	77	25.8	39	43.8
State Colleg	77	49.8	40	51
Wilkes-Barre	75	43.8	41	19.8
Williamsport	76	55.2	41	15
Willow Grove	75	9	40	12
RHODE ISLAND				
Block Island	71	34.8	41	10.2
Nth Kingston	71	25.2	41	36
Providence	71	25.8	41	43.8
SOUTH CAROLINA				
Anderson	82	43.2	34	30
Beaufort	80	43.2	32	28.8
Charleston	80	1.8	32	54
Columbia	81	7.2	33	57
Florence	79	43.2	34	10.8
Greenville	82	21	34	51
Mcentire	80	4.8	33	55.2
Myrtle Beach	78	55.8	33	40.8
Shaw AFB	80	28.2	33	58.2
Spartanburg	81	57.6	34	55.2
SOUTH DAKOTA				
Aberdeen	98	25.8	45	27
Brookings	96	4.8	44	18
Chamberlain	99	19.2	43	48
Custer	103	3.6	43	46.2
Ellsworth	103	0.6	44	9
Huron	98	13.2	44	22.8
Lemmon	102	10.2	45	55.8
Mitchell	98	1.8	43	46.2
Mobridge	100	25.8	45	31.8
Philip	101	3.6	44	3
Pierre	100	16.8	44	22.8
Rapid City	103	4.2	44	3
Redig	103	19.2	45	9.6
Sioux Falls	96	43.8	43	34.8
Watertown	97	9	44	55.2
Yankton	97	22.8	42	55.2
TENNESSEE				
Bristol	82	2.4	36	28.8
Chattanooga	85	1.2	35	1.8
Clarksville	87	25.2	36	37.2
Crossville	85	4.8	35	57
Dyersburg	89	2.4	36	1.2
Jackson	88	55.2	35	36
Knoxville	83	58.8	35	49.2
Memphis Intl	90	0	35	3
Monteagle	85	30.6	35	9
Nashville	86	40.8	36	7.2
Smyrna	86	3	36	0
TEXAS				
Abilene	99	40.8	32	25.2
Alice	98	1.8	27	43.8
Amarillo	101	4.2	35	13.8
Austin	97	4.2	30	18
Bergstrom Af	97	40.8	30	12
Big Sky	101	28.8	32	23.4
Big Spring	101	27	32	18
Brownsville	97	25.8	25	54
Brownwood	98	57.6	31	47.4
Carswell AFB	97	25.8	32	46.8
Chase NAS	97	40.2	28	22.2
Childress	100	16.8	34	25.8
College Stn	96	22.2	30	34.8
Corpus Chrst	97	3	27	46.2
Cotulla	99	13.2	28	27
Dalhart	102	33	36	1.2
Dallas/FW	97	1.8	32	54
Del Rio	100	55.2	29	22.2
Dyess AFB	99	51	32	25.8
El Paso	106	2.4	31	48
Ellington Af	95	10.2	29	37.2
Fort Worth	97	21	32	49.2
Ft Hood Aaf	97	43.2	31	9
Galveston	94	52.2	29	16.2
Gray AFB	97	49.8	31	4.2
Greenville	96	4.2	33	4.2
Guadalupe	104	4.8	31	49.8
Harlingen	97	40.2	26	13.8
Hondo	99	10.2	29	21
Houston	95	21	29	58.2
Junction	99	46.2	30	30
Kelly AFB	98	34.8	29	22.8
Kerrville	99	4.8	29	58.8
Killeen	97	40.8	31	4.8
Kingsville	97	49.2	27	30
Laredo Intl	99	28.2	27	31.8
Laughlin AFB	100	46.8	29	22.2
Longview	94	43.2	32	22.8
Lubbock	101	49.2	33	39
Lufkin	94	45	31	13.8
Marfa	104	1.2	30	22.2
Mcallen	98	13.8	26	10.8
Midland	102	10.8	31	57
Mineral Wlls	98	4.2	32	46.8
Palacios	96	15	28	43.2
Paris/Cox	95	27	33	37.8
Plainview	101	42.6	34	10.2
Port Arthur	94	1.2	30	34.8
Reese AFB	102	3	33	36
Rockport	97	1.8	28	4.8
San Angelo	100	3	31	22.2
San Antonio	98	28.2	29	31.8
Sanderson	102	25.2	30	10.2
South Brazos	95	52.2	28	1.8
Stephenville	98	10.8	32	13.2
Temple	97	25.2	31	9
Tyler/Pounds	95	2.4	32	22.2
Victoria	96	55.2	28	51
Wichita Flls	98	3	33	58.8
Wink	103	1.2	31	46.8
UTAH				
Blanding	109	46.8	38	1.8
Bullfrog Mar	110	4.2	37	30
Cedar City	113	0.6	37	42
Delta	112	34.8	39	19.8
Eagle Range	113	4.2	41	3
Green River	110	9	39	0
Hanksville	110	43.2	38	22.2
Hill AFB	111	58.2	41	7.2
Logan	111	51	41	46.8
Milford	113	1.8	38	43.2
Moab	109	45	38	46.2
Ogden	112	1.2	41	10.8
Price/Carbon	110	45	39	37.2
Prov	111	43.2	40	13.2
Roosevelt	110	37.8	40	30
Saint George	113	3.6	37	4.8
Salt Lake Ct	111	58.2	40	46.8
Tooele	112	1.2	40	10.2
Vernal	109	31.2	40	27
Wendover	114	3	41	13.2
VERMONT				
Burlington	73	9	44	28.2
Montpelier	72	34.2	44	12
Newport	72	19.8	45	33
Rutland	73	57	43	31.8
St Johnsbury	72	1.2	44	25.2
Wilmington	72	52.8	42	52.8
VIRGINIA				
Charlottes	78	27	38	7.8
Chesapeake	76	1.2	37	30
Danville	.79	19.8	36	34.2
Fort Belvoir	77	10.8	38	43.2
Fort Eustis	76	37.2	37	7.8
Hot Springs	79	49.2	37	57
Langley AFB	76	22.2	37	4.8
Lynchburg	79	1.2	37	19.8
Newport News	76	3	37	7.8
Norfolk NAS	76	16.8	36	55.8
Norfolk Rgnl	76	1.2	36	54
Oceana NAS	76	1.8	36	49.2
Quantico Mca	77	1.8	38	30
Richmond	77	19.8	37	30
Roanoke Muni	79	58.2	37	19.2
Staunton	78	51	38	16.2
Volens	78	58.8	36	57
Wallops Sta	75	28.8	37	51
WASHING-TON				
Bellingha	122	31.8	48	48
Bremerton	122	46.2	47	28.8
Burlington	122	19.8	48	30
Colville	118	28.2	48	52.8
Ephrata	119	31.2	47	19.2
Everet/Paine	122	16.8	47	55.2
Fairchild	117	39	47	37.2
Fort Lewis	122	34.8	47	4.8
Hanford	119	3.6	46	34.2
Hoquia	123	58.2	46	58.2
Mcchord AFB	122	28.8	47	9
Moses Lake	119	19.2	47	12
Oak Harbor	122	40.8	48	15
Olympia	122	5.4	46	58.2
Omak	119	31.8	48	25.2
Pasco	119	7.2	46	16.2
Port Angeles	123	3	48	7.2
Pullman	117	7.2	46	45
Quillayute	124	33	47	57
Renton	122	13.2	47	30
Seattle	122	1.8	47	27
Shelton	123	9	47	15
Spokane	117	31.8	47	37.8
Tacoma	122	34.8	47	16.2
Toledo	122	4.8	46	28.8

	LONGITUDE degrees	min	LATITUDE degrees	min
Walla Walla	118	16.8	46	6
Wenatchee	120	1.2	47	24
Whidbey Is	122	39	48	21
Yakima	120	31.8	46	34.2
WEST VIRGINIA				
Beckley	81	7.2	37	46.8
Bluefield	81	13.2	37	18
Charleston	81	3.6	38	22.2
Clarksburg	80	13.8	39	16.8
Elkins	79	51	38	52.8
Huntington	82	33	38	22.2
Lewisburg	80	2.4	37	52.2
Martinsburg	77	58.8	39	24
Morgantown	79	55.2	39	39
Parkersburg	81	25.8	39	21
Wheeling	80	39	40	10.8

	LONGITUDE degrees	min	LATITUDE degrees	min
Wh Sulphur	80	1.2	37	27.6
WISCONSIN				
Appleton	88	31.2	44	15
Eau Claire	91	28.8	44	52.2
Green Bay	88	7.8	44	28.8
Janesville	89	1.8	42	37.2
La Crosse	91	15	43	52.2
Lone Rock	90	10.8	43	12
Madison	89	19.8	43	7.8
Manitowac	87	40.2	44	7.8
Milwaukee	87	5.4	42	57
Mosinee	89	40.2	44	46.8
Neenah	88	31.8	44	13.2
Oshkosh	88	34.2	44	0
Rhinelander	89	27	45	37.8
Rice Lake	91	43.2	45	28.8
Volk Fld	90	16.2	43	55.8
Wausau	89	37.2	44	55.2

	LONGITUDE degrees	min	LATITUDE degrees	min
WYOMING				
Big Piney	110	0.6	42	34.2
Casper	106	28.2	42	55.2
Cheyenne	104	49.2	41	9
Cody	109	1.2	44	31.2
Douglas	105	22.8	42	45
Evanston	111	0	41	19.8
Gillette	105	31.8	44	21
Jackson	110	43.8	43	36
Lander	108	43.8	42	49.2
Laramie	105	40.8	41	19.2
Moorcroft	104	48.6	44	21
Rawlins	107	1.2	41	48
Riverton	108	27	43	3
Rock Springs	109	4.2	41	36
Sheridan	106	58.2	44	46.2
Worland	107	58.2	43	58.2
Yellowstone	110	25.2	44	33

CANADA

CITY	PROVINCE	LONGITUDE		LATITUDE	
Calgary	Alberta	114	7	51	14
Churchill	Newfoundland	94	0	58	45
Coppermine	Northwest Terr.	115	21	67	49
Edmonton	Alberta	113	25	53	34
Frederickton	New Brunswick	66	40	45	57
Ft Mcpherson	Northwest Terr	134	50	67	29
Goose Bay	Newfoundland	60	20	53	15
Halifa	Nova Scotia	63	34	44	39
Hazelton	BC	127	38	55	15
Kenora	Ontario	94	29	49	47
Labrador City	Labrador	66	52	52	56
Montreal	Quebec	73	39	45	32
Mt. Logan	Yukon	140	24	60	34
Nakina	Yukon	132	48	59	12
Ottawa	Ontario	75	45	45	18
Peace River	Alberta	117	18	56	15
Pr. Edward Isl	Nova Scotia	63	9	46	14
Quebec	Quebec	71	15	46	50
Regina	Saskatchewan	104	38	50	30
Saskatoon	Saskatchewan	101	32	52	10
St. Johns	Newfoundland	52	43	47	34
Toronto	Ontario	79	23	43	39
Vancouver	BC	123	7	49	16
Victoria	BC	123	20	48	26
Whitehorse	Yukon	135	3	60	43
Winnipeg	Manitoba	97	9	49	53

INTERNATIONAL

CITY	COUNTRY	LONGITUDE		LATITUDE	
Aberdeen	Scotland	2	9 w	57	9 n
Adelaide	Australia	138	36 e	34	55 s
Amsterdam	Holland	4	53 e	52	22 n
Ankara	Turkey	32	55 e	39	55 n
Asunción	Paraguay	57	40 w	25	15 s
Athens	Greece	23	43 e	37	58 n
Auckland	New Zealand	174	45 e	36	52 s
Bangkok	Thailand	100	30 e	13	45 n
Barcelona	Spain	2	9 e	41	23 n
Belém	Brazil	48	29 w	1	28 s
Belfast	Northern Ireland	5	56 w	54	37 n
Belgrade	Yugoslavia	20	32 e	44	52 n
Berlin	Germany	13	25 e	52	30 n
Birmingha	England	1	55 w	52	25 n
Bombay	India	72	48 e	19	0 n
Bordeau	France	0	31 w	44	50 n
Bremen	Germany	8	49 e	53	5 n
Brisbane	Australia	153	8 e	27	29 s
Bristol	England	2	35 w	51	28 n
Brussels	Belgium	4	22 e	50	52 n
Bucharest	Romania	26	7 e	44	25 n
Budapest	Hungary	19	5 e	47	30 n
Buenos Aires	Argentina	58	22 w	34	35 s
Cairo	Egypt	31	21 e	30	2 n
Canton	China	113	15 e	23	7 n
Cape Town	South Africa	18	22 e	33	55 s
Caracas	Venezuela	67	2 w	10	28 n
Chihuahua	Mexico	106	5 w	28	37 n
Chongqing	China	106	34 e	29	46 n
Copenhagen	Denmark	12	34 e	55	40 n
Córdoba	Argentina	64	10 w	31	28 s
Darwin	Australia	130	51 e	12	28 s
Dublin	Ireland	6	15 w	53	20 n
Durban	South Africa	30	53 e	29	53 s
Edinburgh	Scotland	3	10 w	55	55 n
Frankfurt	Germany	8	41 e	50	7 n
Georgetown	Guyana	58	15 w	6	45 n
Glasgow	Scotland	4	15 w	55	50 n
Guatemala City	Guatemala	90	31 w	14	37 n
Guayaquil	Ecuador	79	56 w	2	10 s
Hamburg	Germany	10	2 e	53	33 n
Hammerfest	Norway	23	38 e	70	38 n
Havana	Cuba	82	23 w	23	8 n
Helsinki	Finland	25	0 e	60	10 n
Hobart	Tasmania	147	19 e	42	52 s
Iquique	Chile	70	7 w	20	10 s
Irkutsk	Russia	104	20 e	52	30 n
Jakarta	Indonesia	106	48 e	6	16 s
Johannesburg	South Africa	28	4 e	26	12 s
Kingston	Jamaica	76	49 w	17	59 n
La Paz	Bolivia	68	22 w	16	27 s
Leeds	England	1	30 w	53	45 n
Lima	Peru	77	2 w	12	0 s
Liverpool	England	3	0 w	53	25 n
London	England	0	5 w	51	32 n
Lyons	France	4	50 e	45	45 n
Madrid	Spain	3	42 w	40	26 n
Manchester	England	2	15 w	53	30 n
Manila	Phillipines	120	57 e	14	35 n
Marseilles	France	5	20 e	43	20 n
Mazatlán	Mexico	106	25 w	23	12 n
Mecca	Saudi Arabia	39	45 e	21	29 n
Melbourne	Australia	144	58 e	37	47 s
Mexico City	Mexico	99	7 w	19	26 n
Milan	Italy	9	10 e	45	27 n
Montevideo	Uruguay	56	10 w	34	53 s
Moscow	Russia	37	36 e	55	45 n
Munich	Germany	11	35 e	48	8 n
Nagasaki	Japan	129	57 e	32	48 n
Nagoya	Japan	136	56 e	35	7 n
Nairobi	Kenya	36	55 e	1	25 s
Nanjing	China	118	53 e	32	3 n
Naples	Italy	14	15 e	40	50 n
Newcastle	England	1	37 w	54	58 n
Odessa	Ukraine	30	48 e	46	27 n
Osaka	Japan	135	30 e	34	32 n
Oslo	Norway	10	42 e	59	57 n
Panama City	Panama	79	32 w	8	58 n
Paramaribo	Surinam	55	15 w	5	45 n
Paris	France	2	20 e	48	48 n
Beijing	China	116	25 e	39	55 n
Perth	Australia	115	52 e	31	57 s
Plymouth	England	4	5 w	50	25 n
Rio de Janeiro	Brazil	43	12 w	22	57 s
Rome	Italy	12	27 e	41	54 n
Salvador	Brazil	38	27 w	12	56 s
Santiago	Chile	70	45 w	33	28 s
St. Petersburg	Russia	30	18 e	59	56 n
Sao Paulo	Brazil	46	31 w	23	31 s
Shanghai	China	121	28 e	31	10 n
Sofia	Bulgaria	23	20 e	42	40 n
Stockholm	Sweden	18	3 e	59	17 n
Sydney	Australia	151	0 e	34	0 s
Tananarive	Madagascar	47	33 e	18	50 s
Teheran	Iran	51	45 e	35	45 n
Tokyo	Japan	139	45 e	35	40 n
Tripoli	Libya	13	12 e	32	57 n
Venice	Italy	12	20 e	45	26 n
Veracruz	Mexico	96	10 w	19	10 n
Vienna	Austria	16	20 e	48	14 n
Warsaw	Poland	21	0 e	52	14 n
Wellington	New Zealand	174	47 e	41	17 s
Zürich	Switzerland	8	31 e	47	21 n

Appendix D - RS-232 Connection

To make a RS-232 connection with the NexStar , the hand control must be in *RS-232 mode* – which can be accessed through the Menu button. Once in the RS-232 mode, the hand control still has the following abilities

- **Direction buttons** – Allowing you to move the telescope in both directions
- **Rate changes** – Allows you to change the telescope's rate of speed when using the direction buttons.
- **Und** – Use to escape from RS-232 mode.

Protocol:

NexStar5 communicates at 9600 bits/sec, No parity and stop bit.. All angles are communicated with 16 bit numbers

Before all commands, the following INITIALIZATION is necessary

- PC sends one byte (63=Ascii "?") to check that NexStar is ready.
- NexStar responds with one byte (35) when NexStar is ready to respond. After NexStar sends a 35, the buttons to the hand control do not respond until the command from the PC has been received, then the direction, rate, and undo buttons are active.

Goto RA-Dec positions

- INITIALIZATION
- PC sends (82=Ascii "R")
- PC sends the RA high byte, RA low byte, Dec high byte, Dec low byte.
- When the scope is finished slewing, it will send back a "@".

Goto Alt-Az positions

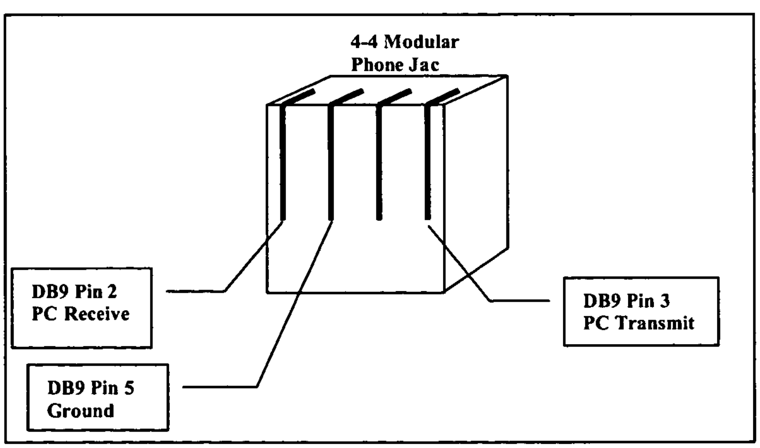
- INITIALIZATION
- PC sends (65=Ascii "A")
- PC sends the Azm high byte, Azm low byte, Alt high byte, Alt low byte.
- When the scope is finished slewing, it will send back a "@".

Get RA-Dec positions:

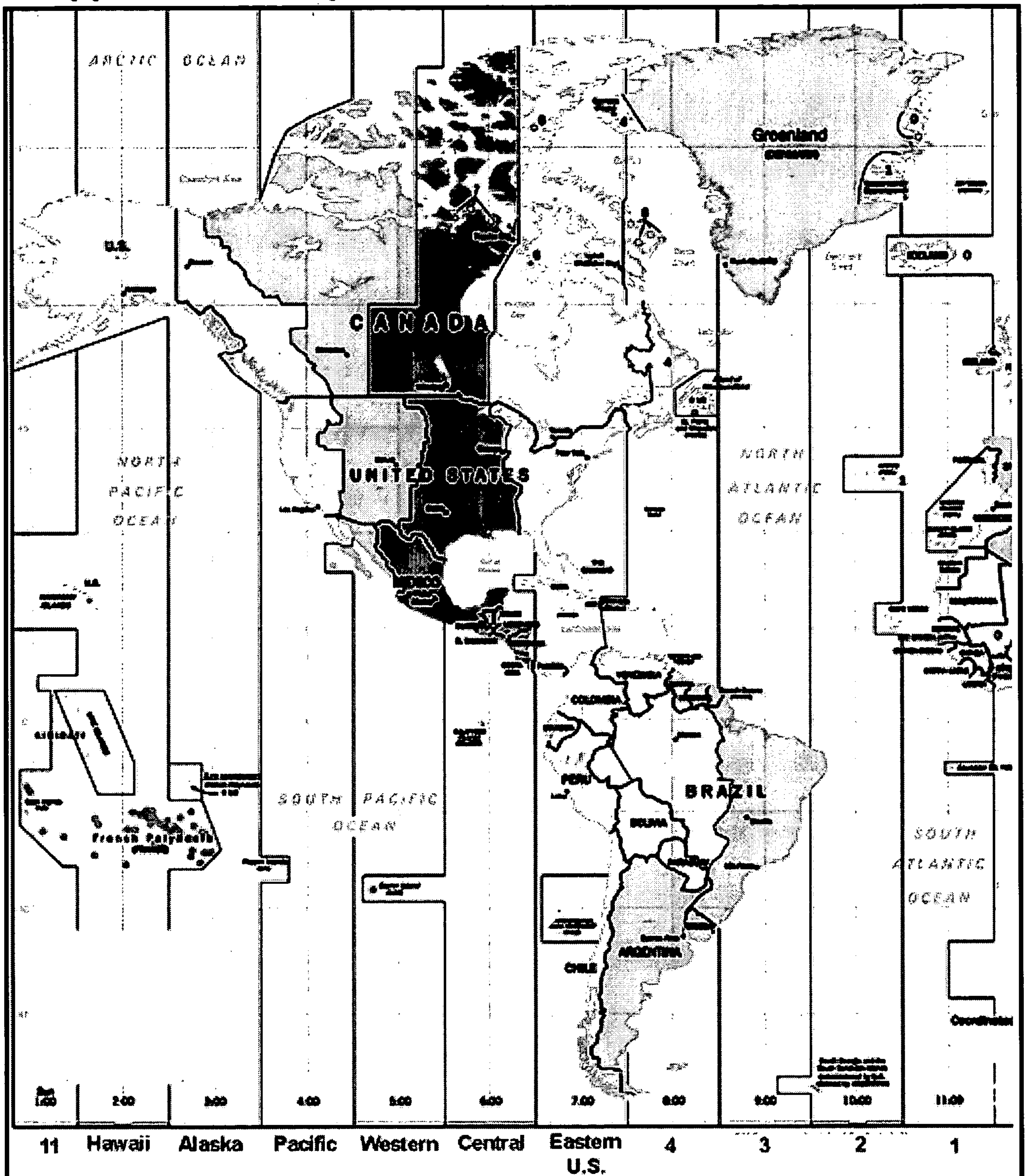
- INITIALIZATION
- PC sends (69=Ascii "E")
- NexStar sends the RA high byte, RA low byte, Dec high byte, Dec low byte.

Get Alt-Az positions:

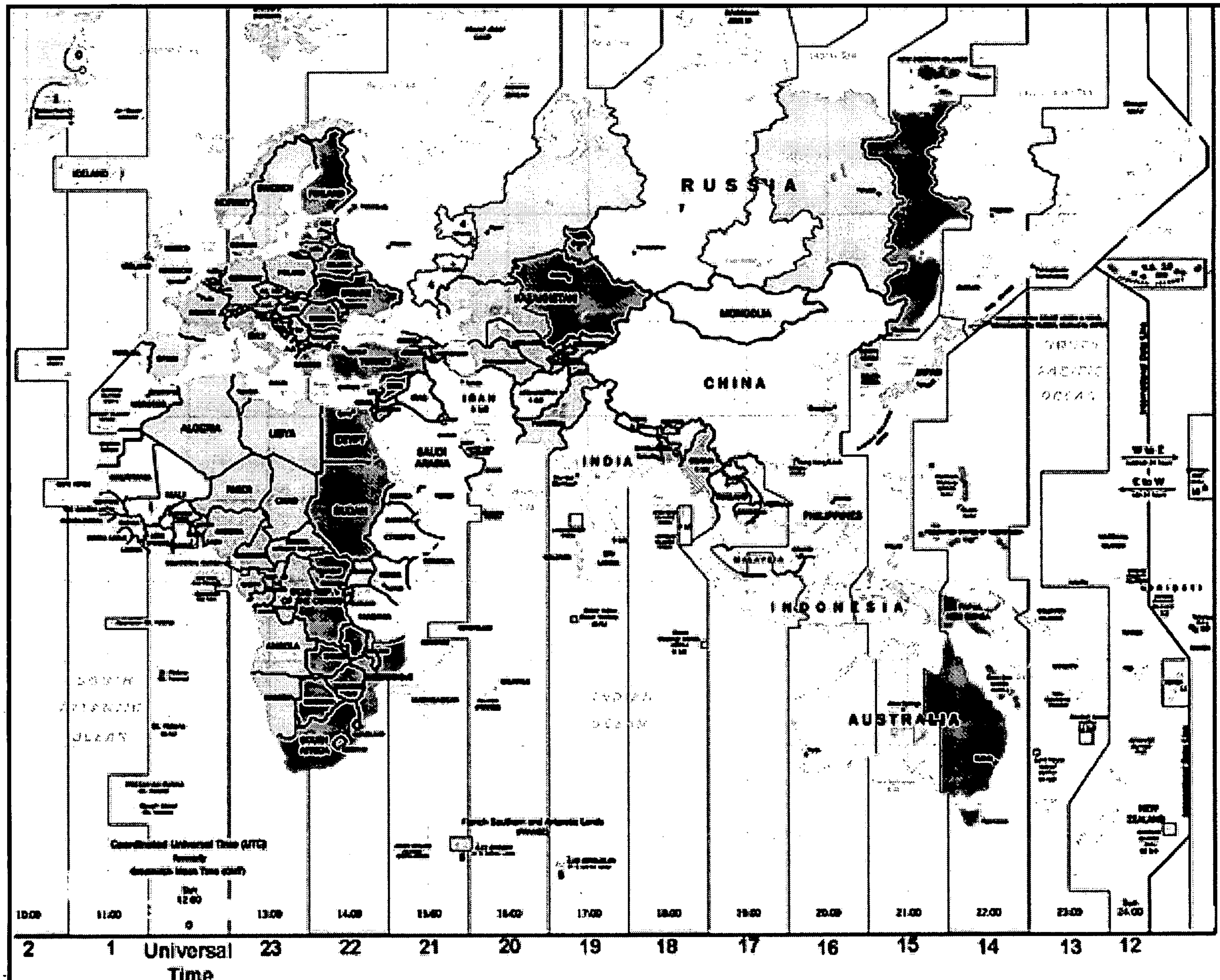
- INITIALIZATION
- PC sends (90=Ascii "Z")
- NexStar sends the Azm high byte, Azm low byte, Alt high byte, Alt low byte.



Appendix E – Maps of Time Zones



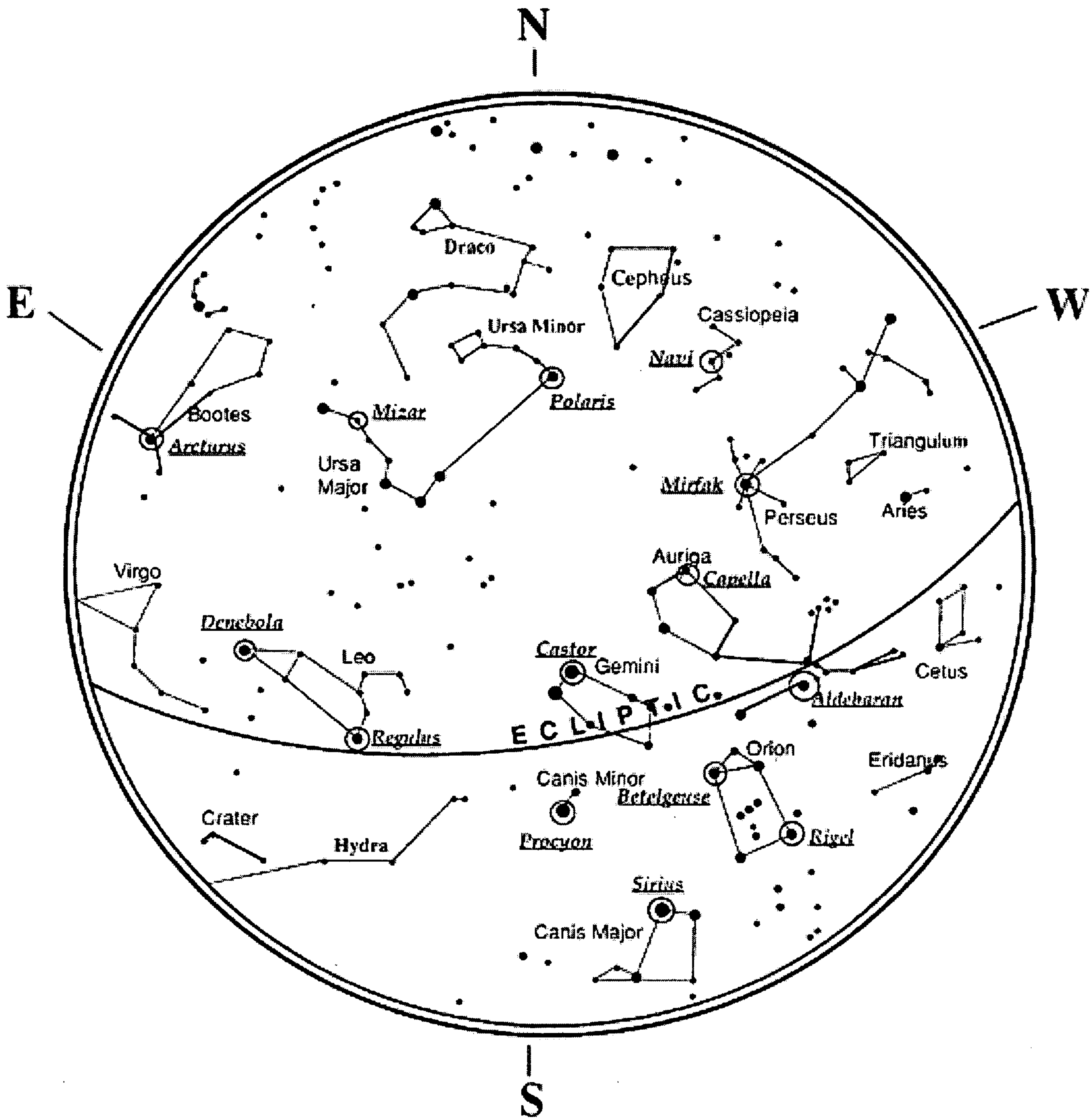
Time Zones



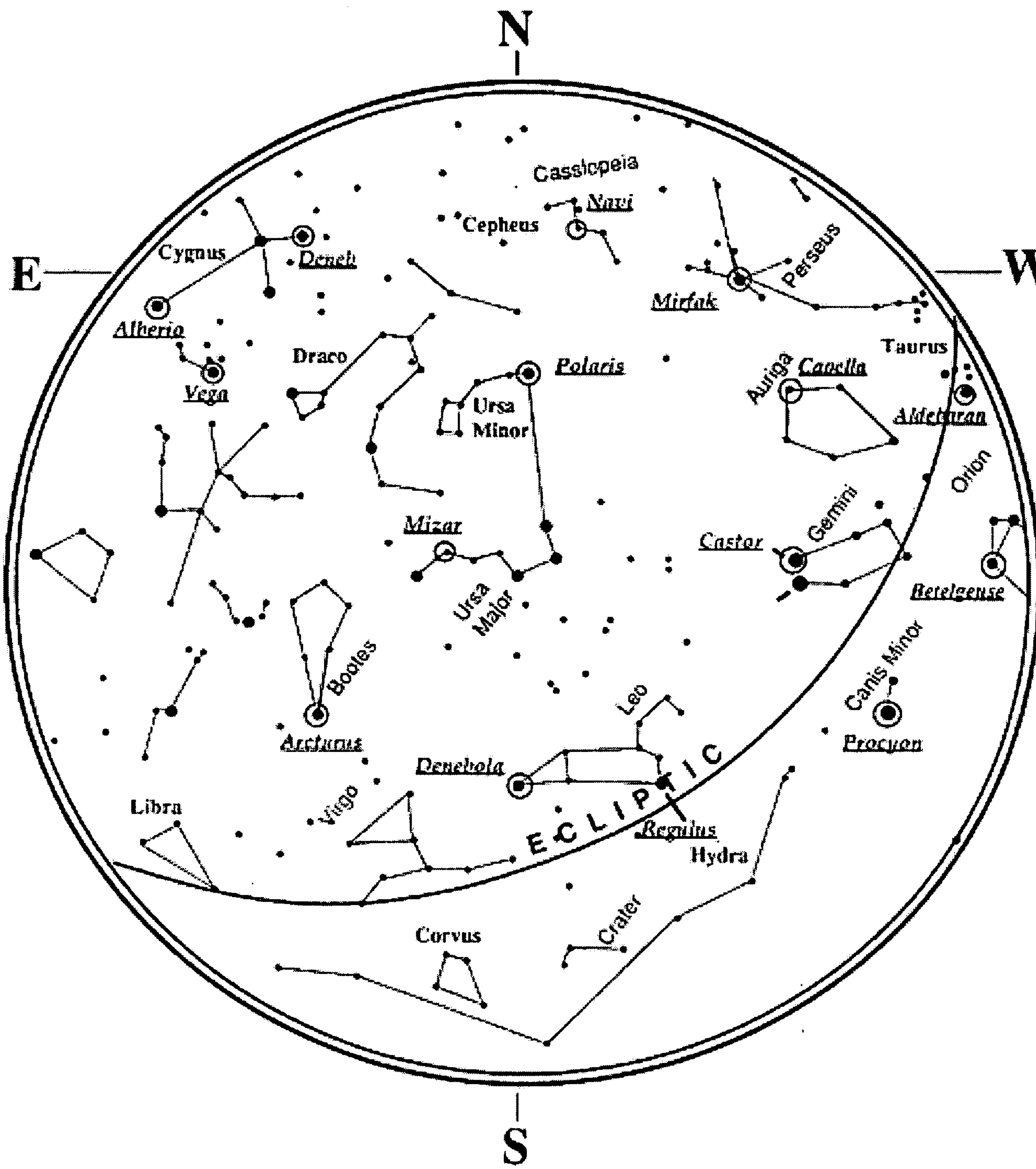
RUSSIA
MONGOLIA
CHINA
INDIA
IRAN
SAUDI ARABIA
ALGERIA
LIBYA
EGYPT
SUDAN
ANGOLA
SOUTH AFRICA
ICELAND
KAZAKHSTAN
PHILIPPINES
MALAYSIA
INDONESIA
AUSTRALIA
NEW ZEALAND
2
1
Universal Time
23
22
21
20
19
18
17
16
15
14
13
12

Time Zones

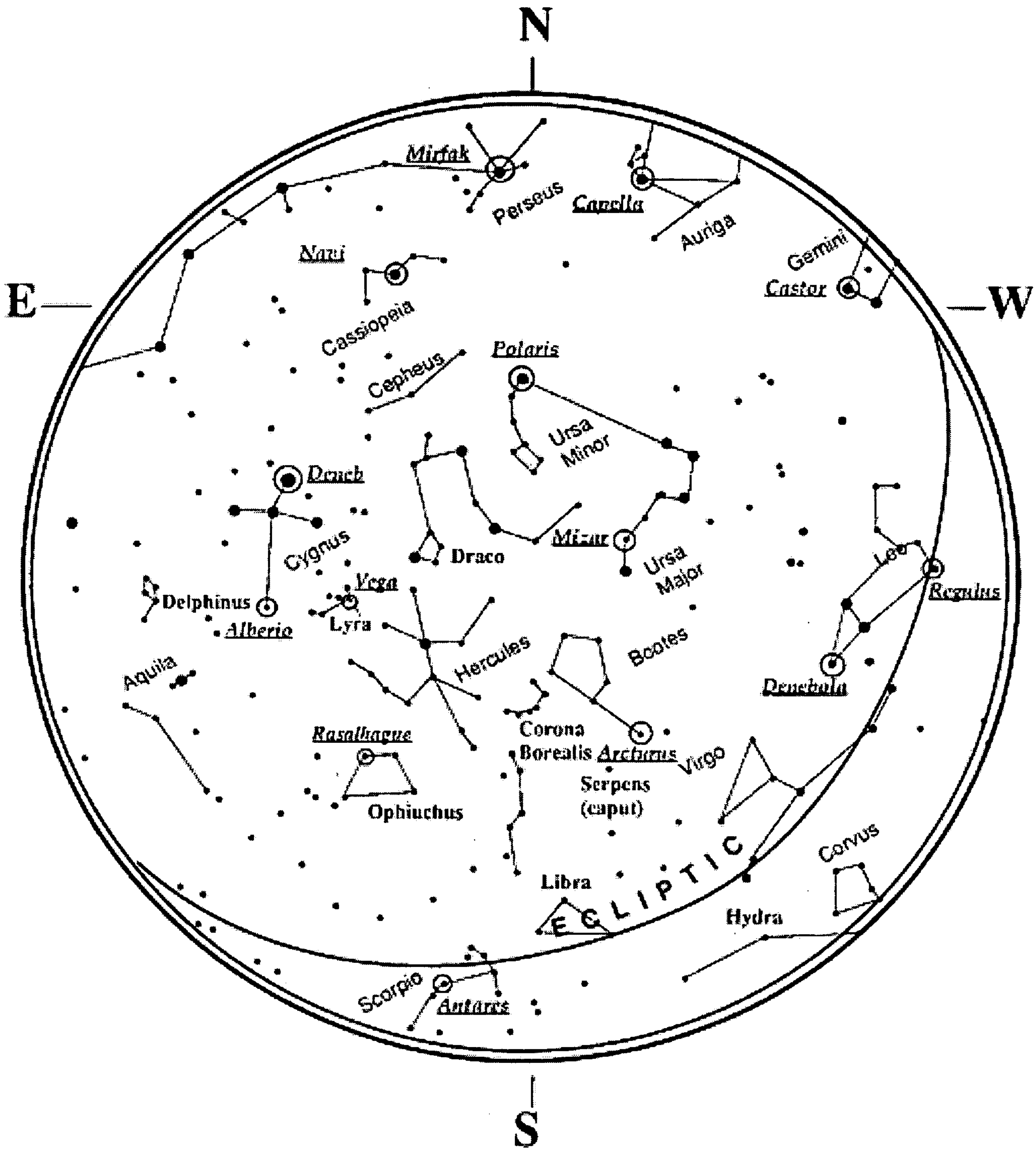
January - February Sky



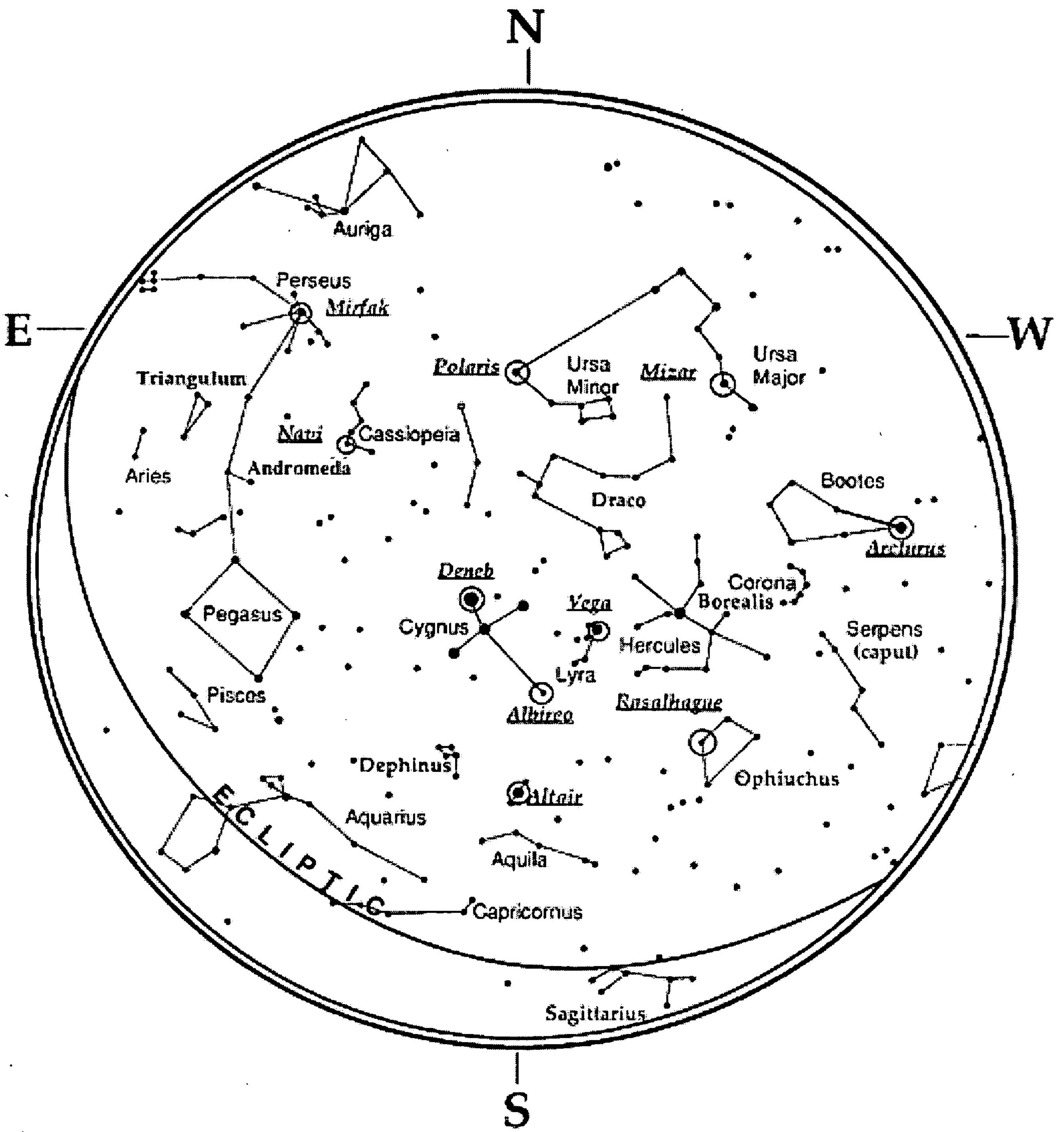
March - April Sky



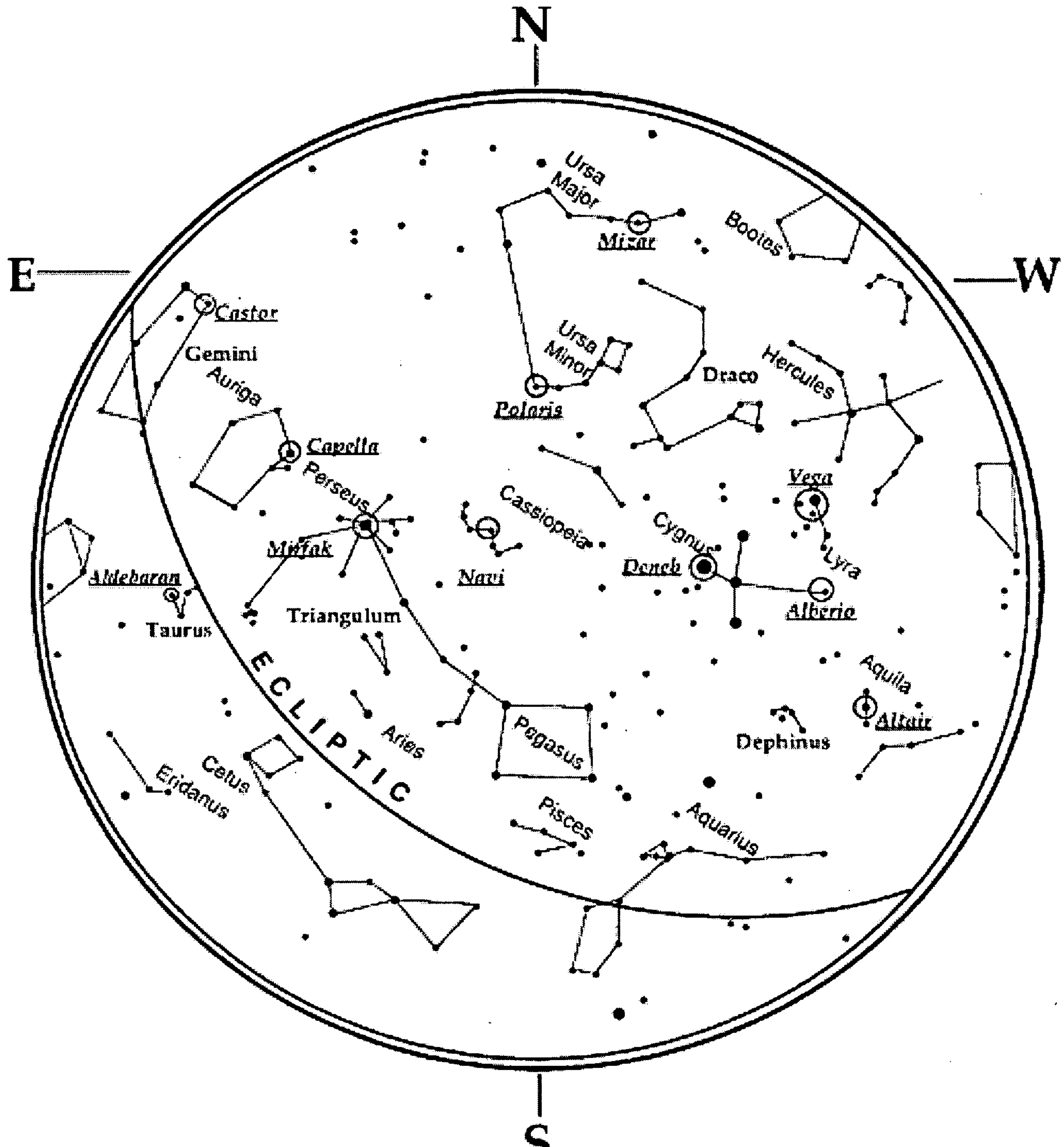
May - June Sky


N
E
W
S
Mirfak
Perseus
Capella
Auriga
Gemini
Castor
Navi
Cassiopeia
Cepheus
Polaris
Ursa Minor
Deneb
Cygnus
Draco
Mizar
Ursa Major
Vega
Lyra
Delphinus
Alberio
Aquila
Hercules
Bootes
Leo
Regulus
Denebola
Rasalhague
Ophiuchus
Corona Borealis
Arcturus
Virgo
Serpens (caput)
Libra
ECLIPTIC
Corvus
Hydra
Scorpio
Antares

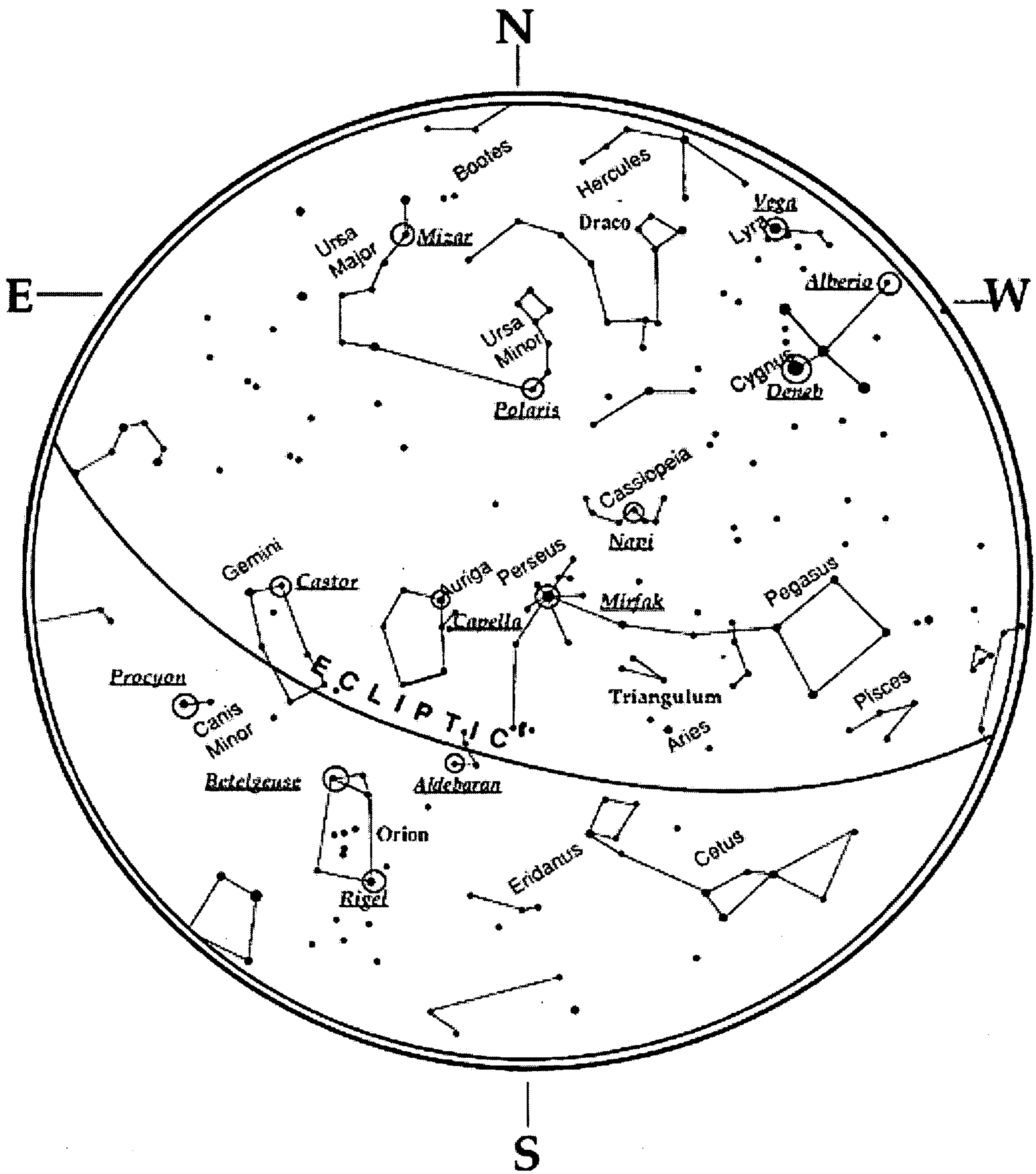
July - August Sky



September - October Sky



November - December Sky



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A. Celestron International (CI) warrants this telescope to be free from defects in materials and workmanship for one year. CI will repair or replace such product or part thereof which, upon inspection by CI, is found to be defective in materials or workmanship. As a condition to the obligation of CI to repair or replace such product, the product must be returned to CI together with proof-of-purchase satisfactory to CI.

B. The Proper Return Authorization Number must be obtained from CI in advance of return. Call Celestron at (310) 328-9560 to receive the number to be displayed on the outside of your shipping container.

All returns must be accompanied by a written statement setting forth the name, address, and daytime telephone number of the owner, together with a brief description of any claimed defects. Parts or product for which replacement is made shall become the property of CI.

The customer shall be responsible for all costs of transportation and insurance, both to and from the factory of CI, and shall be required to prepay such costs.

CI shall use reasonable efforts to repair or replace any telescope covered by this warranty within thirty days of receipt. In the event repair or replacement shall require more than thirty days, CI shall notify the customer accordingly. CI reserves the right to replace any product which has been discontinued from its product line with a new product of comparable value and function.

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Torrance, CA 90503
Tel. (310) 328-9560
Fax. (310) 212-5835
Monday-Friday 8AM-4PM PST

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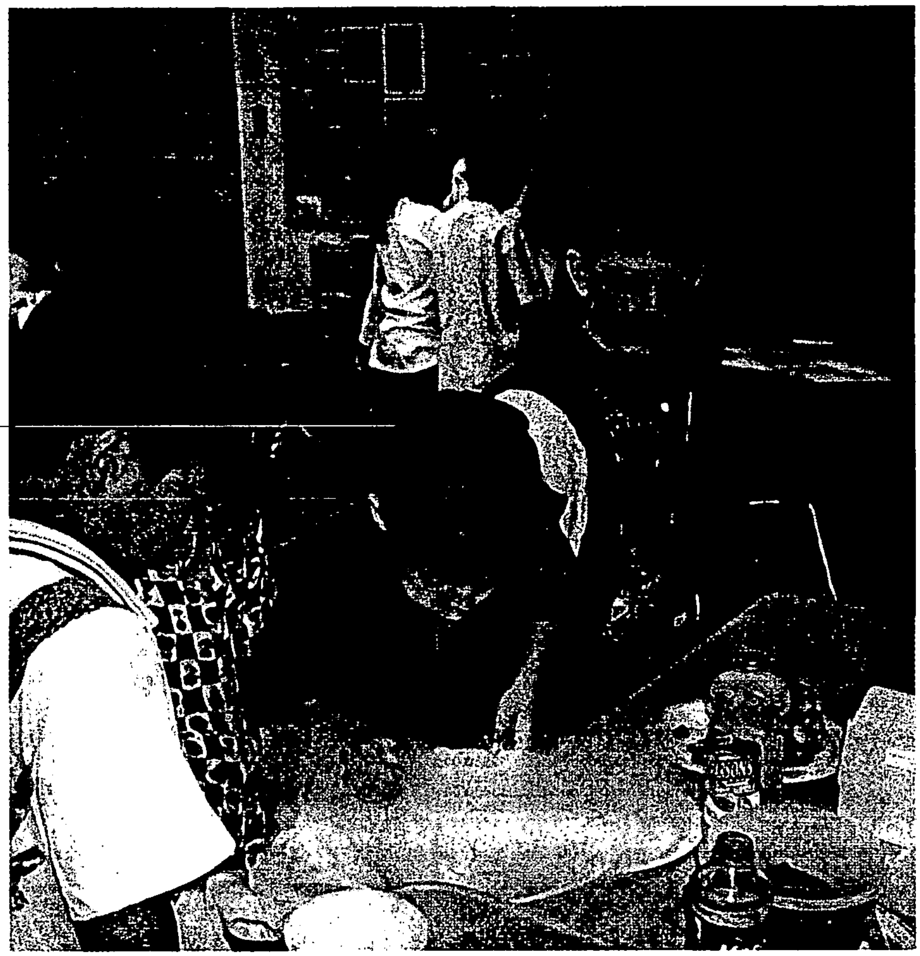
Where Are the Young Astronomers?

Kids still love astronomy, but these days they're rare commodities in organized settings. | **By J. Kelly Beatty**

LIKE HUNDREDS OF OTHER SKY-watching groups across the United States, the Concordia Astronomy Club in Jamesburg, New Jersey, boasts an active, dues-paying membership that meets monthly to hear guest speakers and swap stories of observing prowess. Recently the club purchased a Celestron NexStar 8-inch telescope to shorten the lines at its star parties. Yet all this enthusiasm belies the fact that Concordia's 146 members are 70 years old on average. "It's actually 72, maybe more," corrects founder Eli Drapkin.



GINNY BEAL AND AURA / NOAO / NSF

Comet Making 101. Students at Harelson Elementary School in Tucson, Arizona, are fascinated with dry ice in a hands-on classroom activity sponsored by Project Astro.

The Concordia situation is unusual, if not unique. "We all live in a retirement community of 3,400 residents," Drapkin explains, "and the minimum age for residency is 55." Nonetheless, its graying membership is symbolic of circumstances found throughout organized amateur astronomy. More often than not, ours is a pursuit dominated by older devotees. This demographic skewing is not by choice, of course, and the obvious dearth of young amateur astronomers in recent years is worrying club officers everywhere.

Hard statistics on the scope of the "age enhancement" problem are few. For example, the Astronomical League does not track age among its 18,000 members. However, anecdotal evidence can be seen at virtually any club meeting or star party. Moreover, if the subscribers to major astronomy magazines are any indication, the average skygazer is much older than the general population. For example, a 1998 survey of U.S. subscribers to *Sky & Telescope* yielded a median age of 48, whereas the median age in the United States as a whole is only 33. In 1979, more than a third of *S&T*'s readers were under 30; today only 7 percent of them are.

This gray-out is not unique to amateur astronomy. The same trend is seen among bird watchers, for example. According to a study by MediaMark Research, between 1994 and 1998 median ages jumped sharply — by up to 15 years — among readers of special-interest publications like *Health, Audubon,* and *Consumers Digest.* But not every hobby or avocation is suffering. The United States Chess Federation reports that junior memberships have increased more than tenfold over the last decade.

Do kids still like astronomy — and, if not, why not? The 1998 *Sky & Telescope* survey offers one interesting clue: Among those who had subscribed for two years or less, 64 percent did not develop an interest in astronomy until after reaching 30. By contrast, the great majority (85 percent) of long-term subscribers say they caught the astro-bug by age 16. Much of this latter group, the 40- and 50-somethings of astronomy, came of age at a time when space exploration was a worldwide obsession, light pollution practically nonexistent, and the Internet decades away. The commercial-telescope industry was only in its infancy, but everyone had easier "access" to dark nighttime skies.

Astronomy still has allure, but today it

competes with a vast array of other activities for the time and attention of any would-be observer, young or old. Moreover, today's youth appear less able than ever before to distinguish astronomy from the paranormal and pseudoscientific offerings of the entertainment industry. A recent poll of 1,600 first-year students at York University in Ontario revealed that 53 percent of science majors believe in astrology to some degree. That's up a stunning 16 percent from 1991's response to the same question. Using questions like these, York astronomers Michael M. De Robertis and Paul A. Delaney discovered what many educators have suspected for some time: students' scientific literacy and critical-thinking skills have, on the whole, become seriously deficient.

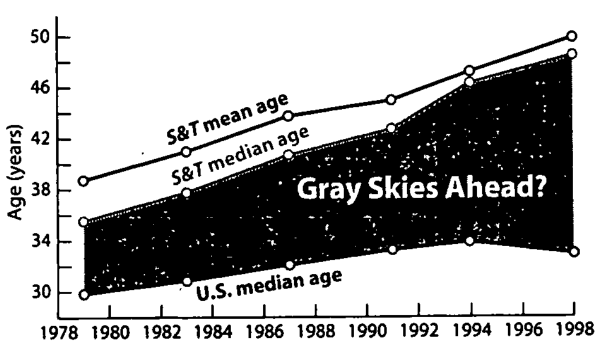
(It's worth noting that astronomical awareness is not much better among their elders. According to the National Science Foundation's *Science & Engineering Indicators 1998*, 27 percent of U.S. adults believe the Sun orbits the Earth, not vice versa, and more than half do not realize that Earth circles the Sun in one year.)

School Daze

Giving these sobering statistics, a first-order question is how much kids are learning about the Sun and stars in school. All students in Great Britain and France get a basic introduction to astronomy at some point during their education, but it is rarely offered in school curricula at any level in the United States. When the National Research Council issued a highly publicized set of National Science Education Standards in 1995, astronomy was hardly mentioned at all — let alone elevated to the level of a worthwhile educational activity. As kid-friendly astronomy popularizer David H. Levy sees it, in an era when Hubble Space Telescope images zip directly into classrooms via the Internet, "most school districts do not encourage an activity as simple as looking at the sky."

The irony in all of this is that young children continue to be just as fascinated with the night sky and telescopes as ever. "The peak age for getting them started seems to be around 10 or 11, when they are naturally most curious," observes Ed Ting, who frequents many classrooms on behalf of the New Hampshire Astronomical Society. "Elementary teachers *love* teaching their astronomy units," adds Benjamin J. Senson, observatory director for the Madison [Wisconsin] Metropolitan School District, but they rarely have any real skygazing experience. "The outcome of all this is a body of incredibly motivated young people who view the enterprise as one of endless, but really cool facts."

Then comes middle school, what Senson terms "the domain of Earth science and biology." There the gee-whiz wonderment of the natural world is frequently replaced by a tedious emphasis on how to gather data and prepare lab reports. Once students reach high school, the chance to learn astronomy ends for all but a very few. Senson is not pleased by this setup: "We have a tremendously powerful system that cuts children



The average (mean) age of *Sky & Telescope's* U.S. subscribers has grown much faster than that of the U.S. population as a whole. The close spacing of the *S&T* mean and median curves in recent years implies that the average age is not being strongly skewed by a relatively small number of very old subscribers.

DOUGLAS DUNCAN

S&T: J. KELLY BEATTY (2)

Top: When it comes to attracting adolescents to amateur astronomy, most clubs appear to be dropping the ball. Here a class of students at the University of Chicago act out Galileo's legendary test of gravity. *Middle:* Robert Isaacs (with name tag) and Ken Slavens coordinate the Tacoma Astronomical Society's innovative program for junior skywatchers. *Bottom:* At the 1998 Table Mountain Star Party, Slavens readies a full house of youngsters for a hands-on astronomy activity.

off from the discipline of astronomy just as they become mature enough conceptually, mathematically, and socially to really pursue it as a potential hobby or career."

Educators seem to agree that when middle and high schools offer astronomical instruction, the response is high. "You wouldn't believe the number of students and *teachers* who go crazy when they see the Moon for the first time through a telescope," says Michael Ford, an educator in Holton, Kansas, and a member of the Northeast Kansas Amateur Astronomers League. However, he cautions, "At age 15, when these students get to high school, astronomy teachers can either stimulate their interest or destroy it."

Having access to dark nighttime skies certainly helps. Thomas Morin, who has taught astronomy for 20 years at Belmont High School in New Hampshire, says his classes have grown from five students to more than 20 per semester. "We are gifted for the most part with good night skies," Morin notes, and his students often buy their own telescopes and become regulars at his star parties. But even light-choked urban schools can have successful programs. "I am teaching about 70 high-school astronomy students," writes Phil Dauber, an instructor at Alameda High School in California. Being so near San Francisco, Alameda's sky is rarely ideal, and few students own telescopes. "All this said, however," Dauber continues, "there is a lot of student interest in astronomy. Our solution is a heavy reliance on computers and the Internet." He also gives extra credit for trips to nearby Chabot Observatory.

Conceived in 1985 by the late Robert H. Ferguson, the "Striking Sparks" program of the Sonoma County [California] Astronomical Society has awarded quality, built-from-scratch telescopes to more than 100 children. Courtesy Merlin Combs.

Peer Review

"Being an amateur astronomer while going through adolescence isn't easy," admits William Johnson, an *S&T* subscriber from Point Lake Forest, California, in his early 20s. "Over the past 10 years I've been hit with every emotion possible toward astronomy: boredom, nerdiness, and even downright hatred." Often peer pressure comes into play, forcing budding amateurs to hide their interest by day, then skulk off to observe or surf astronomical Web sites by night.

Of course, some teens find astronomy compelling regardless of the distracting "choice saturation" they face. Patrick Kelly, this year's winner of the Astronomical League National Young Astronomer Award, managed to balance serious astronomical research with baseball throughout his high-school years (see page 87). Asaf Shtull-Trauring, who lives in Mizpeh Ramon, Israel, says that he got into telescope making *because* he was a teenager. "I couldn't afford to buy a telescope, so I built one," he explains, using the Internet to draw upon the experience of hundreds of people worldwide.

Among astronomy's young ambassadors is Zoë Rose Treuer, a junior at the University of Minnesota in Duluth and already a seasoned lecturer at the school's Alworth Planetarium. Growing up in Florida, Treuer got hooked on observing at age 10 — then hit a wall of indifference. "There weren't any astronomy clubs in either middle or high school," she explains. "In high school, teacher support was absolutely zero." Fortunately, the Southern Cross Astronomical Society threw her a lifeline. "I was respected by the adults and treated like a member," she recalls. Her confidence buoyed, by age 14 Treuer was tackling the nuances of eclipsing binary stars using a 14-inch telescope and a CCD imager (*S&T*: July 1995, page 100).

These days many U.S. schools are fortifying their science offerings, and students are signing up for them in record numbers. But all too often astronomy remains an afterthought. Nationwide educational programs like Project Astro (www.aspsky.org/project_astro.html) and Hands-On Universe (http://hou.lbl.gov/) have breathed new life into astronomy-oriented classes, but neither program has yet reached its full potential.

To fill the unmet needs of interested students — and to attract younger members — many astronomy clubs now offer

Mimi, the Messier Monster

By Mark Wagner

It was a rare February night between winter drenchings, with just a few clouds here and there. My 11-year-old daughter, Mimi, hadn't been able to use her 10-inch Dob in ages, and I thought "This time of year any clear sky is good sky." So I casually thumbed through an old copy of Wil Tirion's *Sky Atlas 2000.0* to get her attention. It didn't take long. "What do you have that out for, Dad? Is it clear outside?" Before I could finish saying "yes" she was up and heading for her warm clothes.

Mimi lacked only M50, M93, and M83 to bag every Messier object, and tonight the first two were in prime viewing positions. Mimi usually finds her observing targets with the help of my laptop computer, but using the atlas was new to her. She went after M50 first and, after a bit of trial and error, she homed in on a bright large open cluster. "I think I've got it," she announced. How I've grown accustomed to hearing those words since she got her own telescope last year! We checked the chart, and Mimi soon identified several bright stars surrounding the cluster. Another confirmed "hit" for my little Messier Monster.

Immediately she wanted to find M93. Back to the charts she went, insisting on finding the right page herself. "Find the dog's tail," I told her." Angle up to the three stars in a line, then look just west of the middle star." She slewed right to the spot. "It's beautiful," she said, pausing for a good look.

She moved on to M42 in Orion, which showed nicely in the bright city sky. "What else can I look at?" she whimpered. I looked up and said, "Well, how about . . ."

"The Beehive!" she blurted.

Once we'd found it on the chart, she was gone — back at the Telrad finder and, soon, gazing at that lovely treasure chest of stellar gems. "It's not a Beehive; it's a diamond mine," she said, and I had to agree. Before long, Mimi had swept up NGC 2903 in Leo, a beautiful glimpse of M45, an amazingly good view of M1, and the gorgeous little cluster NGC 2362 in Canis Major.

Would she be able to get that last elusive object, M83? The head of Hydra was rising up south of Leo, and I explained that M83 lay low on or perhaps below the horizon. It would have to wait for another time — it was getting late. Then she said something that all good observers come to realize: "You know, Dad, the sky is not just stars any more. When I look up, I see different areas. It's broken up into pieces now." She's only 11, but the constellations are falling into place for her. That wonderful, intimate familiarity with the night will be with her long after I'm gone.

We packed up and went inside. She was a happy monster. I was a happy dad. An hour was all it took.

MARK AND MIMI WAGNER *patrol the night sky from their home in Northern California, and on nearby Fremont Peak. Mimi snared M83, her final Messier object, on March 25th.*

MARSHA ROBINSON

Mimi Wagner and Cassiopeia, her 10-inch reflector, are joined (from left) by Ray Cash, Mark Wagner, Jim Shields, and Steve Gottlieb.

family or junior memberships. Another growing trend is to provide activities designed specifically for kids.

One such effort is "Striking Sparks," a program created in 1985 by members of the Sonoma County Astronomical Society (SCAS). Every year 5½-inch mirror blanks are lovingly ground and polished by 10 different club members, while the tubes and mounts are built by volunteers at a high-school wood shop. Each completed scope costs $175, the money for which is raised by finding various local sponsors. Then students throughout Sonoma County write essays describing why they should get one of the coveted creations. One telescope is sponsored by the Young Astronomers, a kids club within the SCAS comprising Striking Sparks telescope awardees from past years.

Another innovative approach comes from the Tacoma [Washington] Astronomical Society. The early success of a modest session for kids at public observing sessions led to a full-throttle commitment to youth-oriented activities. "It takes an immense amount of dedication," admits Robert Isaacs, who runs the once-a-month program with sidekick Ken Slavens. "We started small and worked up. Today one-fourth of the club's yearly budget goes to student activities — it's our biggest line item."

Both kids at heart, Isaacs and Slavens are regulars at the annual Table Mountain Star Party, where for six years they've concentrated on getting kids to think like kids. Games work particularly well. One hour might be devoted to "Constellation Bingo," another to a kids-only observing session. "We originally thought this would draw more families into our club," says Isaacs. "But we also find youngsters who are interested in astronomy on their own."

Circumstances and resources are unique to each club, and what works in Tacoma may not in Tallahassee. But extensive discussions with astronomy educators, club officers, and young skywatchers themselves suggest that a few common-sense approaches will make amateur astronomy more appealing to skywatchers of any age. Veteran science teacher Morin offers these tried-and-true guidelines:

- push for some kind of astronomy curriculum (even if presented by club volunteers) in the middle- and high-school grades;
- offer observing classes for parents and children alike to familiarize them with the nighttime sky;
- find sponsors or create a foundation to reduce the cost of buying beginners' telescopes;
- provide youth-oriented astronomy programs within your club; and
- get city kids out into the countryside to see what a night sky really looks like.

In the end, we must accept that many youngsters harbor an interest in skygazing that remains hidden from public view. They might shy away from showing it by day, only to hungrily devour the Internet's cosmic offerings at night. Others will retreat from astronomy during adolescence, only to return to it later in life — what teen-turned-adult Johnson likens to a "black hole of interest" that hits around age 12 and lasts until about 30.

"Every amateur astronomer should realize that astronomy isn't for everyone," he warns, "even if your parents are die-hard observers."

Young Astronomer Award Winners

By David Tytell

In 1992, amid dwindling funding for high-school science programs, Charles Allen saw the need to involve more of America's youth in astronomy. He and other key members of the Astronomical League looked for a way to make astronomy and astronomers more accessible to students across the nation. Their answer was the National Young Astronomer Award (NYAA).

Since it was first presented in 1993, the NYAA has been available to high-school students in the United States. To be eligible, an applicant must be between the ages of 14 and 19, have not yet enrolled in college, and have completed some form of astronomical research. The applications are then put through two rounds of judging, with the final round conducted by professional astronomers.

This year's winner is Patrick L. Kelly, a senior at Sidwell Friends School in Washington, D.C., where he organized an astronomy club. In addition to his membership in the Northern Virginia Astronomy Club, for the past three years Kelly has spent his summers at the University of Arizona Alumni Association's Astronomy Camp. Offered through Steward Observatory, this program encourages participants to conduct their own research projects using 40- and 60-inch telescopes atop Mount Lemmon, as well as the 61-inch reflector on Mount Bigelow (see the April issue, page 80).

During the past summer Kelly also worked as an intern at the Carnegie Institution of Washington in Washington, D.C. For his project, entitled "The Color-Magnitude Relation in Hickson Compact Group 62," Kelly was teamed with Daniel Kelson, a Carnegie postdoctoral fellow. Using photometric data Kelson had obtained from the 1-meter Swope telescope at Las Campanas Observatory in Chile, Kelly determined the colors and magnitudes of galaxies within this moderately dense group and used that information to understand the properties and ages of those galaxies. "I analyzed the properties of the color-magnitude plot against those of the high-density Virgo and Coma clusters," explains Kelly. "The slopes of the color-magnitude relations in both environments are similar, but the group galaxies have much greater scatter, which suggests that group galaxies are fundamentally similar to cluster galaxies, just not as mature." Kelly, who will major in astrophysics at Harvard University, hopes to publish his findings in the coming months.

CYNTHIA KELLY

Patrick L. Kelly, this year's winner of the Astronomical League's National Young Astronomer Award, with his first-place prize: a 10-inch LX200 telescope donated by Meade Instruments. Kelly's winning project involved the photometric study of galaxies.

Along with the first-place honor, Kelly received a 10-inch Meade LX200 telescope and an all-expenses-paid trip to Astrocon, the Astronomical League's national convention, last July in Ventura, California. (However, Kelly was not there to receive the award. Instead he was in Rehovot, Israel, doing another astronomical research project, this time as part of the Weizmann Institute of Science's International Summer Science Institute.) Kelly also gets a "lifetime pass" to McDonald Observatory in Texas, which entitles him to share telescope time with the observatory's astronomers.

NYAA's second-place winner this year is Tiffany Titus, a senior at Battle Creek Area Math and Science Center in Michigan. Her project entailed calculating the orbital elements of main-belt asteroid 737 Arequipa. She also received a trip to Astrocon and a lifetime pass to McDonald Observatory. Third place went to Stephanie Fawcett, a junior at Boulder High School in Colorado, for her essay, "Application of Extrasolar Planetary Data in the Search for Extraterrestrial Life Using the Drake Equation."

Robert Gent, vice president of the Astronomical League and NYAA chair, concedes that, though enthusiasm for the award is high, very few students apply. To obtain information about the NYAA, contact Gent at 703-751-6805, bobgent@aol.com; or Terry Mann at 937-678-5032, starsrus@infinet.com; or visit the Astronomical League's Web site at www.astroleague.org.

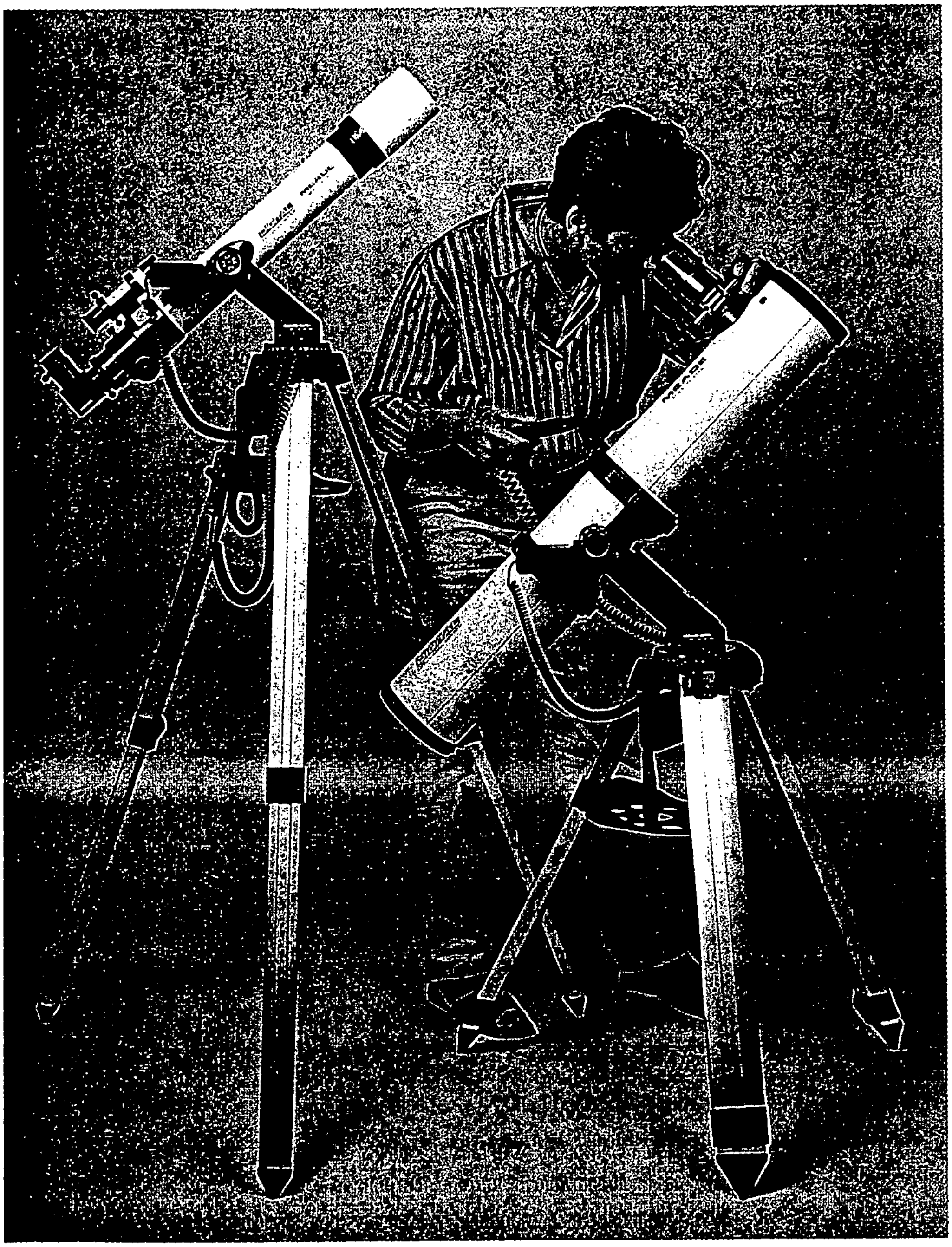
DAVID TYTELL *is in Boston University's science-journalism graduate program and is a* Sky & Telescope *assistant editor.*

Past National Young Astronomer Award Winners

Year	First Place	Title of Project
1999	Elizabeth Fernandez	Active Galaxies in the Perseus Supercluster
[illegible]	[illegible]	[illegible]
1997	Heather Cameron	Solar Observation Station
[illegible]	[illegible]	[illegible]
1995	Heather Castellano	Elements of Impact Crater Formation
[illegible]	[illegible]	[illegible]
1993	Blake Warren Thomas	Spectrographic Analysis of Cepheid Pulsation

Robotic Telescopes for the Masses

Meade's DS line will change the way people think about "department-store" telescopes. | **By Dennis di Cicco**



With the introduction of its new line of Digital Electronic Series (DS) telescopes, Meade has taken a bold step and transferred its Autostar computer-pointing technology to entry-level instruments. The line includes four refractors between 60- and 90-millimeter aperture and 4.5- and 5-inch Newtonian reflectors. The 70-mm refractor and 4.5-inch reflector are pictured here.

OKAY, SO MAYBE I WAS WRONG. In our review of Meade's ETX-90/EC (May issue, page 61), I suggested that this revolutionary telescope might go down in history as the one that changed the way people are introduced to astronomical observing. It now appears that this honor will not go to the ETX but rather to a new line of Meade telescopes. The reason for this revision is summarized with one word — cost.

S&T TEST REPORT

As Leif Robinson correctly pointed out in his Spectrum last May (page 8), it is the "Autostar concept" of a telescope that automatically points to celestial objects that will revolutionize beginner-level astronomy. Meade's new Digital Electronic Series telescopes transfer the multimillion-dollar development of Autostar to inexpensive entry-level instruments — so-called department-store telescopes. Indeed, Meade's own acronym for the new line, the DS telescopes, sounds like a play on the department-store moniker.

Certainly the ETX-90/EC was a breakthrough. It reduced the cost of a computer-pointed telescope by roughly a factor of four. Nevertheless, with a price tag of $750, the system was still a serious investment and more than many would spend

Meade's DS Telescopes

Entry-level refractors and reflectors with an optional computer-pointing system.

Price: Complete systems starting at about $350

Internationally mass-marketed through department, camera, specialty, and telescope stores and through catalog sales

Meade Instruments Corp.
6001 Oak Canyon
Irvine, CA 92620
Phone: 949-451-1450
www.meade.com

PHOTOGRAPHS BY CRAIG MICHAEL UTTER

to test the waters of a new hobby. The DS series, on the other hand, can put a computer-pointed scope in the hands of a budding amateur astronomer for under half the cost of the ETX-90/EC.

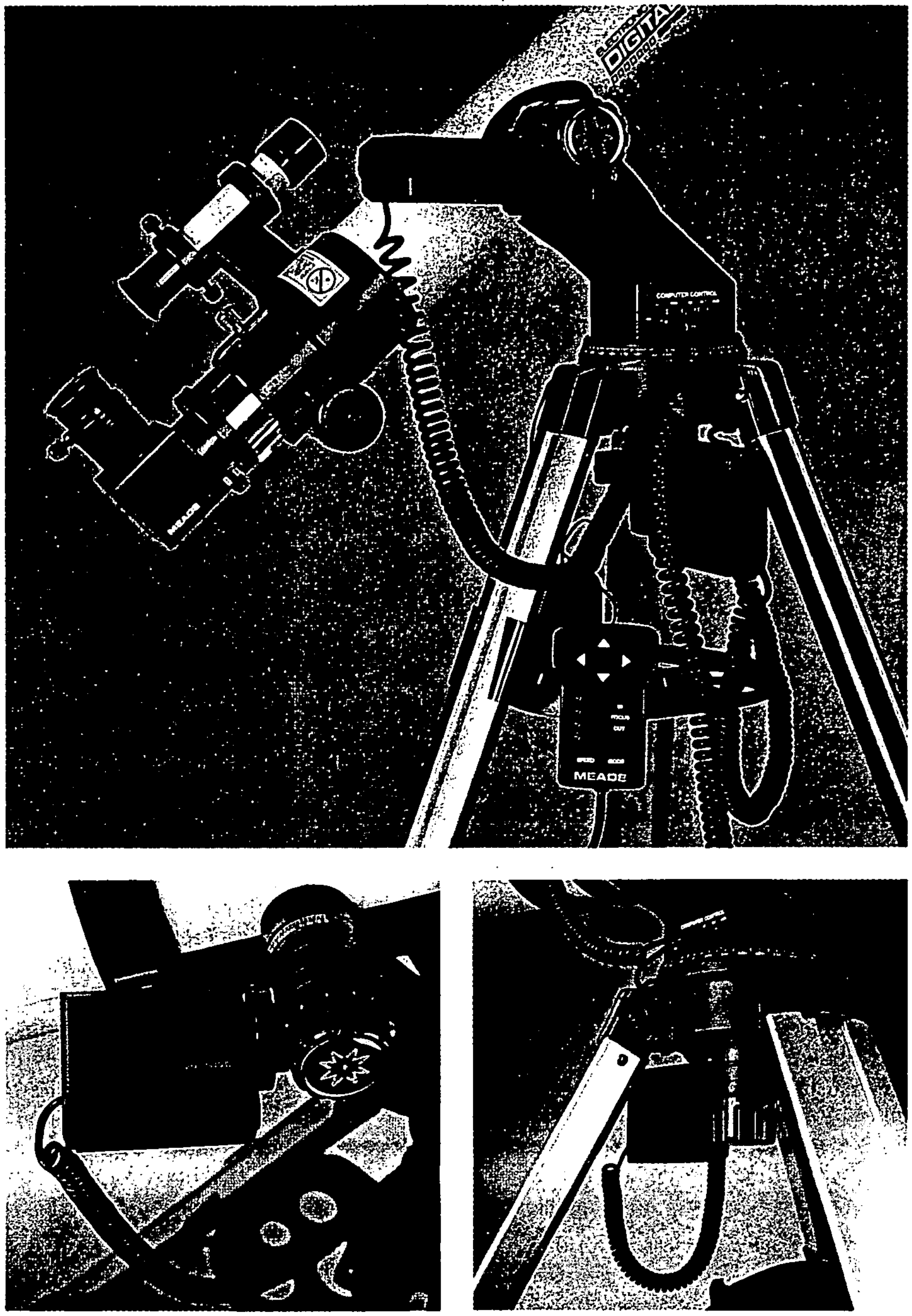
Why Are They Important?

Sales figures remain guarded company secrets, but even conservative estimates by industry insiders suggest that the money spent on department-store telescopes each year is three to four times that spent on "serious" amateur instruments. Because department-store telescopes cost less than serious instruments, there are obviously a lot of department-store scopes sold every year. So why aren't there more amateur astronomers in the world? Many veteran amateurs believe that the telescopes themselves are to blame.

Often of mediocre mechanical quality and supplied with useless high-power eyepieces, department-store telescopes have been anything but user-friendly with their dim, wobbly, fuzzy views. Conventional wisdom holds that people become frustrated trying to use them and give up on astronomy. Whether or not you buy into this theory, the issue should become largely moot with the DS telescopes. It will indeed be interesting to see if they grow the hobby of amateur astronomy.

The DS series includes 60-, 70-, 80-, and 90-millimeter refractors and 4.5- and 5-inch Newtonian reflectors. All come with adjustable aluminum tripods and altazimuth mounts. A more detailed general description of them is difficult because various configurations will be available. This will also make it challenging to price-shop based only on the information typically contained in newspaper and magazine advertisements. For example, in their most basic configuration, the DS series altazimuth mounts merely have friction clutches on the altitude and azimuth axes. But the mounts can also be equipped with either manual or electric slow-motion controls and, of course, the optional Autostar computer-pointing system, the part that works the magic. In most cases the DS scopes will be sold with 1¼-inch eyepieces, but some will have the less-expensive 0.965-inch variety.

Last June, on the eve of the commercial release of the DS scopes, we asked Meade for production models of the 70-mm refractor and 4.5-inch reflector for evaluation. Both were configured as EC models, which come with electric slow motions and a hand control that also supports an optional electric focuser. It is the EC models that are plug-'n'-play ready to accept the Autostar computer system.

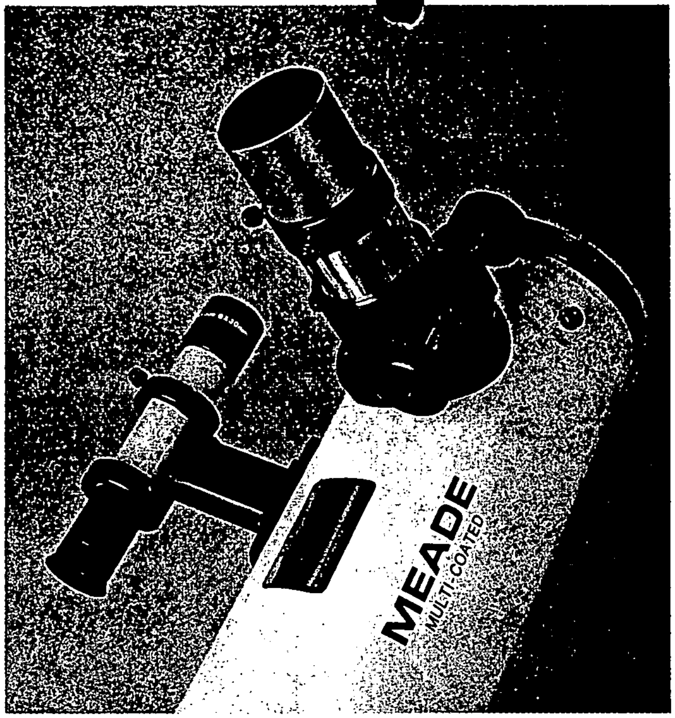


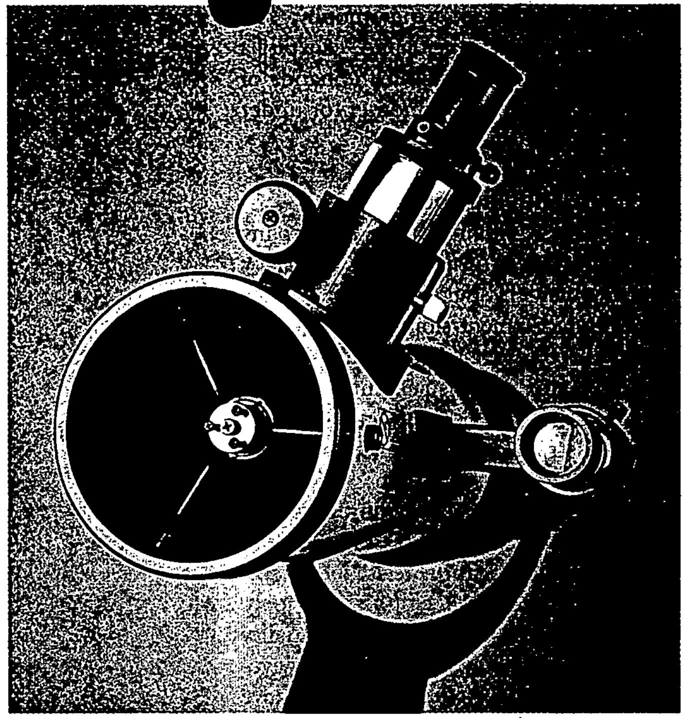
All DS telescopes come with two eyepieces, and the refractors include a mirror star diagonal. They can be fitted with multispeed electric slow motions on both axes that are robust and quiet. The motors make the telescopes plug-'n'-play ready for the Autostar computer-control system.

Some Assembly Required

Both telescopes required a small amount of assembly, all of which was accomplished with a Phillips-head screwdriver. Even those who are mechanically timid should be able to complete the process in well under an hour. The instruction manual is clearly written and accompanied by detailed drawings. Nevertheless, the assembly work is made tedious by the need to flip back and forth in the manual because the written material is on different pages than the diagrams. Also, the "one-size-fits-all" instructions cause you to read passages that are not specific to the scope you are assembling. Even so, I find this far preferable to the poor instructions that accompany most inexpensive telescopes.

Optical collimation of the refractors is fixed at the factory and requires no user adjustment. The reflector also arrived accurately collimated, but it has a full range of adjustments, which makes it easy to keep the optics tuned for opti-





As described in the text, high-quality plastic parts give the DS scopes features not often found on inexpensive instruments. The rack-and-pinion focusers have helical gears and accept both 2- and 1¼-inch eyepieces. The Newtonian reflectors have a full range of collimation adjustments on the secondary mirror support to allow precise optical alignment.

mum performance. Beginners are often unnecessarily intimidated by the collimation process, but those familiar with optical alignment will certainly appreciate the ease with which the DS reflectors can be tweaked for precise collimation.

Meade engineers must have been paying close attention when, in the now-classic scene from *The Graduate*, the key to a successful future was summarized as "plastics." Extensive use of high-quality, injection-molded plastic parts gives the DS scopes features not typically found on inexpensive telescopes. For example, the focusers are made almost entirely of plastic (even the chrome-plated drawtubes), yet they have helical rack-and-pinion gears for smooth operation, a large thumbscrew to adjust friction, and fittings for both 1¼- and 2-inch eyepieces that have solid locking screws.

The plastic parts are very robust and should stand up to years of service. A good example is the bracket for the finderscope.

Our Policy Concerning *S&T* Test Reports

Information is proliferating at an ever-increasing rate. The Internet, especially, allows for widespread dialogue about astronomical products, not all of it well informed or accurate. Below are a description of the mission of *S&T* Test Reports and the ground rules for preparing them. Most of the policies have been in effect since the first report appeared more than a decade ago.

Through these reports, we aim to provide timely, informative, fair, and useful reviews of telescopes, accessories, and other equipment of interest to the astronomical community. To accomplish this, we incorporate the results of field and bench testing done by staff members and/or qualified outside reviewers. Products are chosen by our Test Report Committee of editors, who together have more than a century of experience in backyard astronomy.

Telescopes, eyepieces, and other optical instruments are the principal subjects for Telescopes Plus, but we also review electronic and other accessories. Products for imaging or data gathering, including software, are also reviewed and may appear in Computers in Astronomy or Astro Imaging. All items must be readily obtainable.

Often we purchase our test units anonymously from retailers; when this is not practical we arrange the loan of a unit directly from the manufacturer. Either way, the report will always state how the unit was obtained. Although we acquire the most current model available, manufacturers sometimes make changes before the report is published.

Our goal in every report is to tell readers how a product performs and, specifically, whether this performance is consistent with the manufacturer's claims. Each reader should learn enough from the test report to decide on the suitability of a particular product for his or her needs.

We will note relevant problems discovered during testing and will try to determine whether such shortcomings are peculiar to the test unit or endemic to the product. Sometimes we'll offer suggestions for the use, maintenance, or improvement of a product. When more than one item is reviewed, we may conduct comparative testing to acquaint readers with differences among products.

S&T Test Reports generally include abundant data, and we always make it clear whether this information comes from the manufacturer, our tests, or both. The names and addresses of venders, as well as current off-the-shelf prices, are provided but are subject to postpublication changes.

Manufacturer concerns are subsidiary to our mission of reader service. While venders may be informed about an upcoming *S&T* Test Report, the report itself is not shared with them in advance of publication. The opinions stated in all reports are those of the authors; they are not subject to review by the management of Sky Publishing Corporation, which may not share those opinions.

Leif J. Robinson, *Editor in Chief*

While I wasn't planning any destructive testing, the beefy bracket survived when the refractor accidentally toppled onto a blacktop driveway as I unpacked it from my car. The plastic bracket has a clever design that allows positive (and intuitive) perpendicular adjustments.

The reflector comes with a standard-quality 6×30 finder having a crosshair eyepiece. The refractor's 5×24 finder, on the other hand, has a single-element plastic objective. While the view through it was poor, it was adequate for aiming the telescope at any naked-eye target, which is all that's needed for Autostar setup.

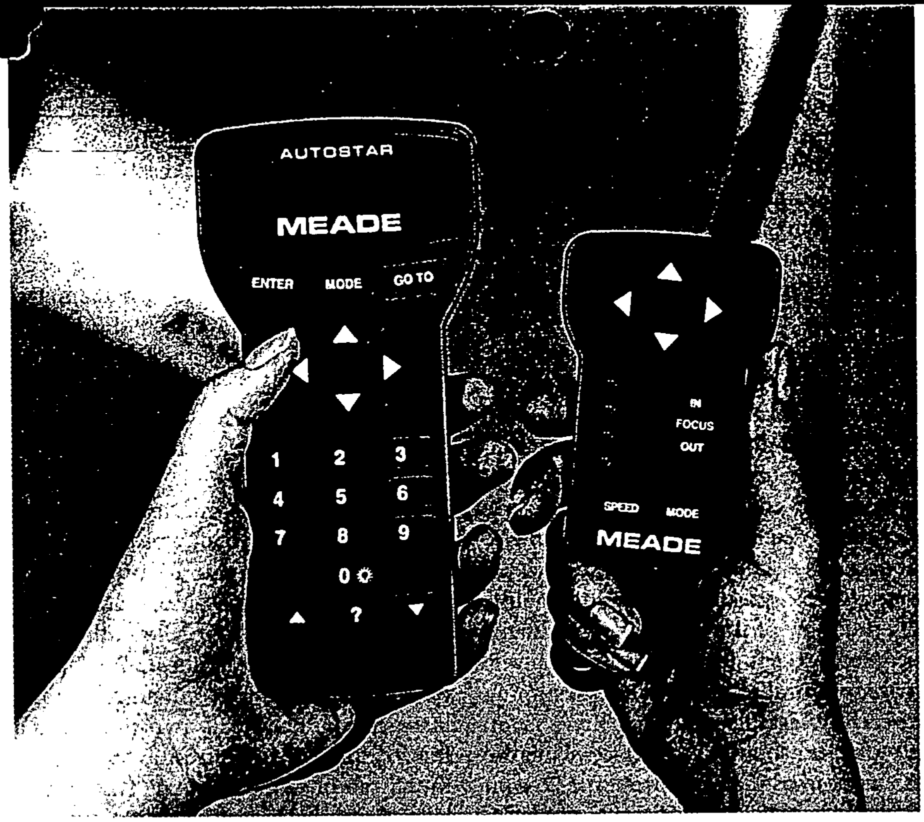
The Optics

The main optics in both telescopes proved to be very good, delivering the performance that I would expect of their respective designs. With an f/8 focal ratio, the reflector's mirror delivered diffraction-limited performance with a spherical surface figure. Star images were clean and tight and came to a crisp focus in the 25- and 9-mm eyepieces supplied with the scope. Lunar views were also crisp and contrasty, thanks in part to the small central obstruction caused by the secondary mirror. This mirror is large enough to provide a fully illuminated field at the center of an eyepiece, but some vignetting occurs toward the edge of low-power fields. This, however, was not visually distracting even when I was viewing in twilight skies with a 2-inch eyepiece.

The refractor's objective is a conventional f/10 doublet made with flint and crown glasses. As would be expected of such a design, some color fringing is evident on bright objects viewed at high magnification. This was most apparent when I was examining Venus with the 9-mm (78×) eyepiece. This fringing also took the "edge" off the contrast when I was looking at the Moon, but the effect is extremely subtle and easily overlooked.

A case in point occurred while I was viewing the waxing crescent Moon last June. A couple out for an early evening stroll was intrigued by the telescope and readily accepted an invitation to look through the 25-mm (28×) eyepiece. Neither had viewed the Moon with a telescope before, and both were amazed to see craters. The experience made their day and, for that matter, mine too!

Colorful double stars like Albireo in Cygnus and Gamma Andromedae were impressive sights in the refractor, as were a surprising number of deep-sky objects, considering the small aperture.



The standard hand controller (right) for the electric slow motions has red LED indicators for the different slewing speeds and will support an optional electric focus motor. The Autostar controller (left) has adjustable backlit buttons and a two-line liquid-crystal display. It is lightweight and ergonomically user-friendly.

Neither telescope has a rock-solid mount, and a deft touch was required when I was focusing at high magnifications. Vibrations, however, damped out fast. The reflector stabilized in about 1 second following a sharp rap on the tube, and the refractor damped even faster. Furthermore, the view always returned to the same position when either telescope was purposely jiggled. The optional electric focuser would allow hands-free, vibration-free operation of the telescope, but this is a luxury rather than a necessity.

The electric slow motions on both scopes were very similar to those on the ETX reviewed last May, with one notable exception: they were much quieter when slewing at maximum speed. No one, sleeping dogs included, will find the whirring noise objectionable. The standard hand control that comes with the EC models moves the telescope at four speeds ranging from a maximum of about 6° per second down to 2 arcminutes per second. Each is selected with the push of a button on the hand control. It quickly became almost second nature to select the right speed for the task at hand, whether moving from target to target, centering objects in the eyepiece, or manually tracking the sky's motion. Since the DS mounts are strictly altazimuth, automatic tracking is possible only with the Autostar controller, which brings us to the heart of the story.

Autostar

As said earlier, it is Autostar's ability to automatically point the telescope to any object in the sky that sets the DS instruments apart from any inexpensive telescopes ever sold before. I was certainly enthusiastic about Autostar after using it with the ETX-90/EC, and, if anything, its potential is greater with the DS scopes. What observer (especially a beginner) wouldn't be excited by the ability to confidently locate celestial targets? And that's only the tip of the iceberg when it comes to what Autostar can do. Other big features for beginners, at least in my opinion, are the astronomical information that Autostar can display about many celestial objects, and the "tours" that are programmed into its memory. The latter will introduce people to planets, star clusters, nebulae, and galaxies that most beginners don't attempt to hunt down. Autostar custom tailors the tours to the date, time, and observer's location.

The Autostar controller for the DS scopes is identical to that for the ETX, with the exception of having fewer objects in its internal database (roughly 1,600 ver-

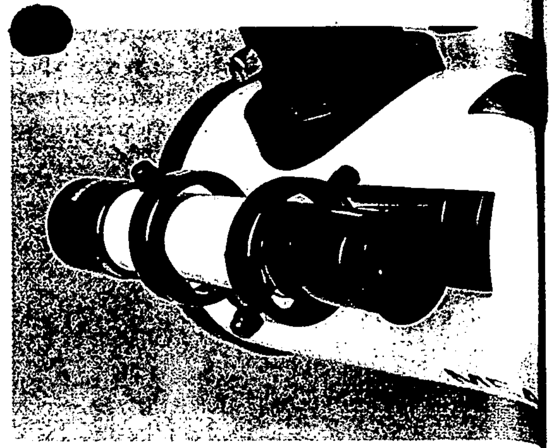
sus 14,000). Priced at $99, it is also $[illegible] less expensive. While 14,000 mostly very faint deep-sky targets might be overkill for small apertures, the light grasp of the 90-mm refractor and both reflectors is equal to or greater than that of the ETX-90/EC, so Meade's marketing strategy is based on more than just what objects are actually within reach of the various telescopes.

Autostar is specifically designed for user updates of the internal software. Version 1.1o was tested with the DS scopes, and any Autostar owner having an earlier version should check out Meade's Web site (www.meade.com) to download a free update. The latest version fixes several bugs. One fix greatly improves the pointing accuracy of the system, especially for people who spend an unusually long time making star alignments at the beginning of each observing session.

Autostar's pointing accuracy with the DS scopes was indeed superb. The 70-mm refractor and 25-mm eyepiece yielded a 1.4° field of view. Every object that I asked the scope to slew to ended up in the field, often within the central half. The longer 900-mm focal length of the 4.5-inch reflector yielded a smaller, 1.1° field with the 25-mm eyepiece. In this case only about 75 percent of the targets ended up within the field, but the misses were just outside the edge. I suspect all would have been within the field of the 2-inch diameter, 50-mm-focal-length eyepiece Meade suggests as an accessory for the DS telescopes — a recommendation that I second.

Despite its advanced capabilities, Autostar is remarkably easy to operate with the DS scopes, even more so than it is with the ETX. This is because the DS mounts have no rotational limits that add steps to the initialization process of the ETX. Just set the DS scope down with the tripod in any position, level the tube, and aim it due north (the "home" position). Turn the power on and follow the instructions that scroll across Autostar's LCD display to initialize the scope with the sky and begin observing! The process takes less than three minutes.

Unless you have previous experience with Autostar, it is important to be in a well-lit environment (indoors is fine) the



The sturdy finder bracket is cleverly designed to provide positive perpendicular adjustments with only two thumbscrews on each ring.

first time you connect the controller to a telescope. This will make it easier to perform several one-time-only setup steps and learn how to navigate Autostar's menus and commands.

Under a night sky the only potential stumbling block that Autostar is likely to present to novice skywatchers involves the initial star alignment. Although Autostar

A Magnetic Star-Finding Machine

S&T TEST REPORT

By Alan M. MacRobert

MANY PEOPLE THINK IDENTIFYING STARS AND CONstellations is a black art. That's because they once tried it and gave up in frustration, victims of one of the many badly designed maps and aids sold to an unknowing public. Unrealistic constellation charts are the norm, showing blobby star patterns that look nothing like what you see in the sky. The instructions often seem written by people who've never found a star themselves. The worst offenders are the ones designed for children. These can be so dumbed down that it would take an Einstein to make them work.

One exasperated user was astronomy teacher Sam Lee of Fort Myers, Florida, who says he "spent decades observing the sky and being frustrated by the limitations of such products." So he invented a new, electronic approach. Night Navigator is a whirring, glowing, beeping device that shows you 16 simple maps covering the major constellations visible from the Northern Hemisphere. It directs you to the correct map and orients you with lights and readouts using a built-in electronic compass.

You begin with a fair amount of setup. Night Navigator takes six batteries of two kinds in three compartments, two of which require a screwdriver to open. You set the time and date about as you would when programming a digital watch, then enter your latitude zone (clearly shown on a map in the instruction manual), your magnetic compass deviation zone (also from a map), your longitude zone (from another map), and whether you're on daylight saving time. This needs to be done only once; the settings are stored in Night Navigator's memory.

Now you're ready to go outdoors. You have the option of finding any of 39 constellations, 18 bright stars, or four planets. You call up the name of your choice by working two buttons, then are told whether the object is currently viewable and, if so, which numbered chart to use. You literally scroll through the charts; they are printed on a long plastic sheet that winds from one roller to another on either side of the 6-inch viewing window. It takes about 35 seconds for the motor to turn the scroll from one end to the other. The charts are nicely backlit, glowing in adjustable red light.

When you've got the correct chart in the window, you hold Night Navigator level in front of you and slowly rotate your whole body until a beeper sounds and a red light flashes. Then, standing still, you rotate Night Navigator itself until it beeps and flashes again. You are then told to look high, medium, or low. The constellations on the map have the same orientation as the constellations you're facing in the sky.

The maps are not sophisticated. Only three sizes of dots represent stars that actually range in brightness by a factor of 100, which is a hindrance to pattern recognition. Patterns appear two or three times smaller on the maps than they do in the sky, though not nearly as small as

Night Navigator

[illegible]

[illegible]

[illegible] Electronics

[illegible] outlets and catalogs.

[illegible] Web site for details.

[illegible]

uses only bright, naked-eye stars for the alignment procedure (two are required), and even though it slews the telescope to their approximate position, the stars are identified only by a common name on Autostar's display. If, for example, you can easily identify Vega and Spica you'll have no problems. For everyone else, a simple planisphere or *Sky & Telescope* evening sky map would be a helpful accessory. Meade does include with all DS instruments a Windows-based sky-charting program called *Star Navigator II*, which may help beginners learn the sky. But human nature being what it is, most people will want to use the telescope before learning new software.

To the Stars

Observing with both telescopes was a lot of fun. The Moon was always a fascinating target. It was easy to follow the changing phase of Venus as our sister planet dropped lower into the June twilight each night. Mars was well past its prime, having shrunk to 13″ diameter; it was small and for the most part bland looking, but there were moments when I caught glimpses of dark surface markings. The deep-sky, however, was particularly intriguing with these instruments. And despite the additional light-gathering power of the reflector, it was the refractor that I really enjoyed simply because of the direct parallel I could draw with my own introduction to deep-sky observing years ago.

Most beginners lack detailed star charts, and this makes it difficult to know if your telescopic gaze has pinpointed an object's location among the stars. Without detailed charts, it's unclear whether the galaxy you're shooting for is unseen because it's too faint or because you're looking in the wrong place. This was certainly a problem for me when I set out to explore the deep sky with a 60-mm refractor in 1963.

Now, 36 summers later, I found myself cruising the heavens with another small refractor. And this time I didn't even have a star chart with me. Nevertheless, the 100 percent pointing accuracy I experienced with the DS refractor left no question in my mind about whether or not I was looking at the right field. After pressing several buttons and waiting a few seconds for the slewing motors to do their thing, I could look into the eyepiece knowing the location was right. Certainly years of observing experience helped, and the 70-mm refractor has about 35 percent more light grasp than a 60-mm, but I was amazed at how much I could see with the DS scope. Just the knowledge that something should be in the eyepiece made me look harder for it, and success was often the reward.

As was the case with the ETX-90/EC, price alone makes it difficult to nitpick the DS telescopes. You have to accept them as fantastic dollar values when you consider that the complete telescope — optical tube assembly, finder, two eyepieces, mount, motor drives, tripod, and even a computer-controlled pointing system — costs about what some people pay for a single premium eyepiece. There are other low-cost, entry-level scopes on the market, and some have appealing features. None, however, has the computer-slewing advantage that the Autostar system offers. The DS telescopes stand alone in today's market. They are remarkable.

on traditional planispheres or printed all-sky charts.

Night Navigator can also be used in reverse mode to identify an unknown bright star or planet you see outdoors. It comes with a nice introductory astronomy booklet that talks about everything from why the sky is blue to what you can see with binoculars.

The Kid Test

If you hope to find stars without reading many pages of instructions, Night Navigator is not for you. In contrast, the fold-out constellation map in *Sky & Telescope* shows star patterns realistically (though small) and requires only three short paragraphs of instructions. Yet the paper map covers the evening sky more completely than Night Navigator and makes it easier to see your way from a constellation to its neighbors.

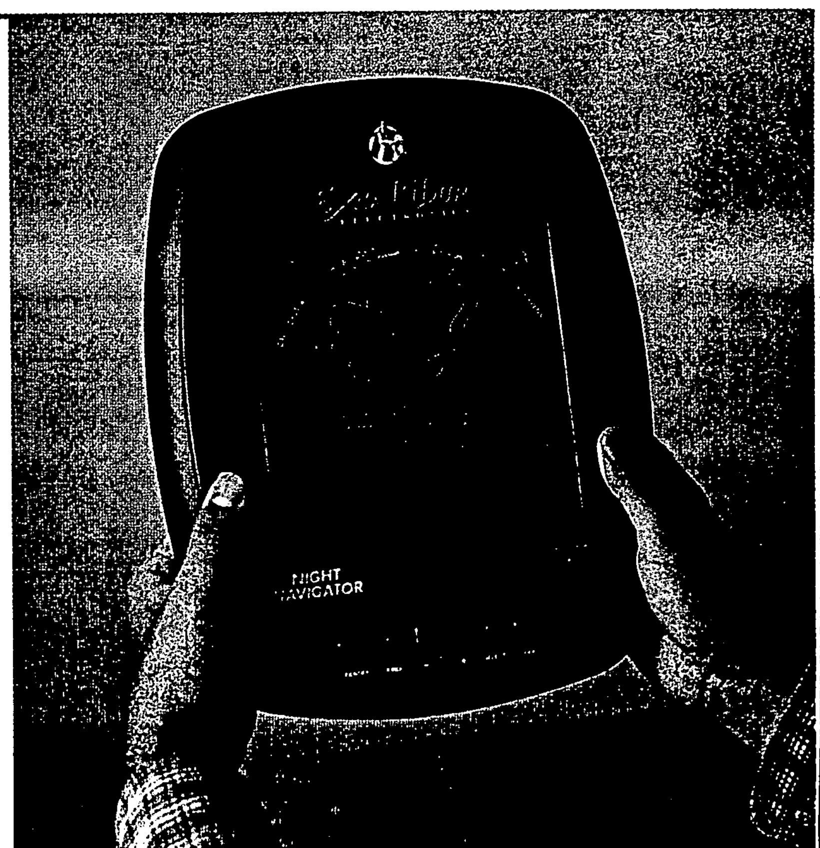
Intrigued by Night Navigator's lights, sounds, and scrolling charts, my 13-year-old daughter was eager to try it out. I set it up, told her the procedures, and helped her get started outdoors, the way any parent might. She was then able to locate Leo and Vega with it on her own in a few minutes, though the device pointed her in slightly the wrong direction for Leo. I next had her try using the *Sky & Telescope* map with a flashlight. She quickly identified Mars and Spica, Corvus, Arcturus, and the Big Dipper.

"I like the map better," she declared.

Why?

"It's faster and easier."

Parents will note that the map costs well under $99.95 and does not need batteries or a screwdriver.

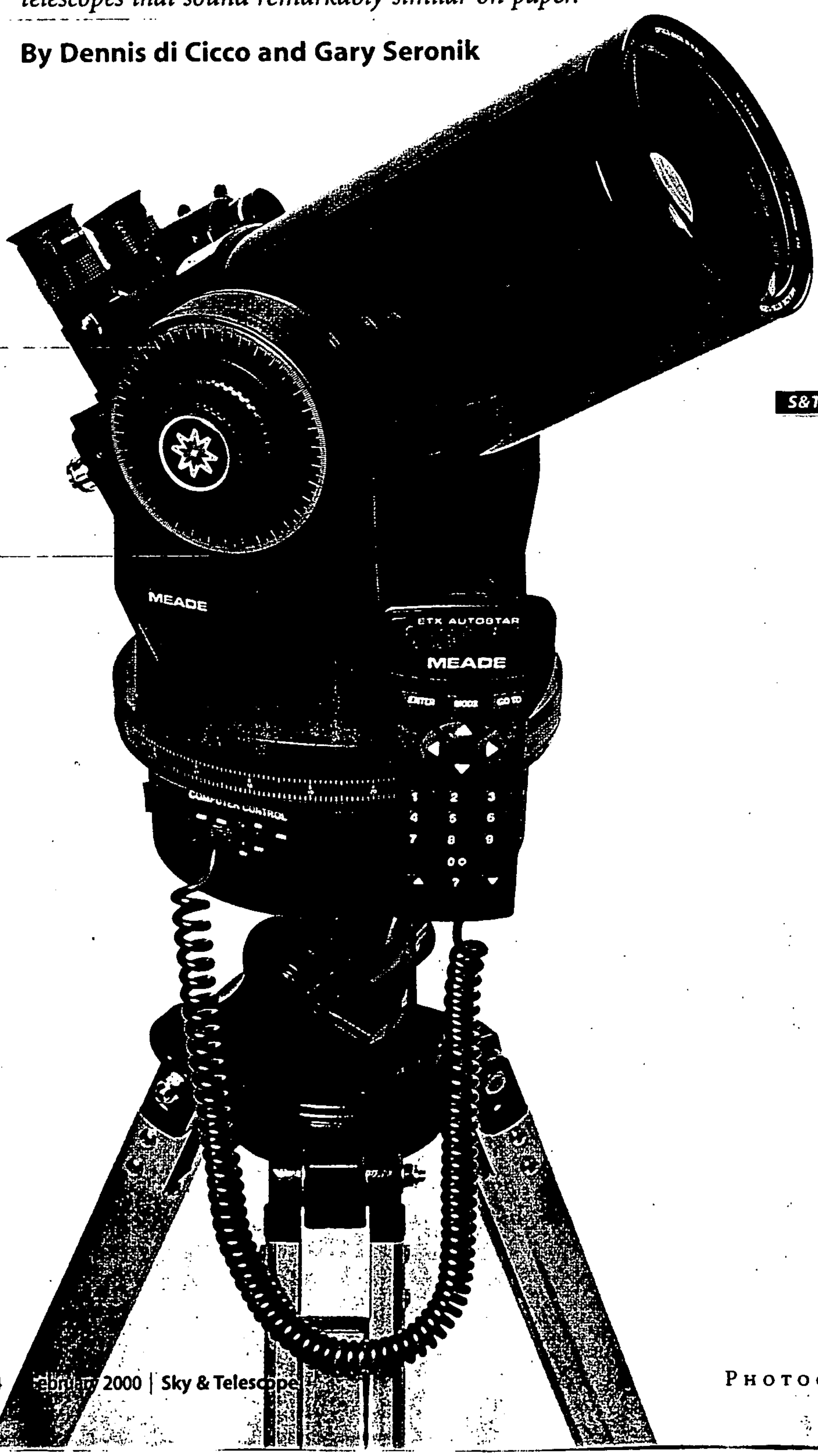


The internal clock and electronic compass in Night Navigator govern the star-finding instructions that it displays for you.

Go To Telescope Showdown

Once again Celestron and Meade are competing head to head with telescopes that sound remarkably similar on paper.

By Dennis di Cicco and Gary Seronik



CELESTRON VERSUS MEADE. No hardware topic seems to generate more heated discussion among amateurs than the decades-old debate about which of these leading manufacturers builds better telescopes. The debate intensified last year when both companies unveiled instruments that are among the hottest of hot products introduced during 1999. These are, of course, the Meade ETX-125EC and the Celestron NexStar 5 — a pair of 5-inch catadioptric telescopes on computerized Go To mounts. Hype aside, which of the two is better? To find out, we spent several intensive weeks field- and bench-testing units supplied by Celestron and Meade as well as another pair purchased at random. Here's what we learned.

S&T TEST REPORT

Meet the Contenders

In some respects, neither of these telescopes is completely new. The NexStar is based on an optical tube assembly that has been in and out of production since the early 1970s. With minor mechanical tweaks along the way, it has grown better with age. The ETX is a scaled-up version of the 90-millimeter (3½-inch) scope that Meade introduced in mid-1996 and outfitted with computerized pointing last year. Our first-look review of the ETX-125EC (October 1999 issue, page 61) mentioned several shortcomings. Rectifying these and some unexpected problems that arose from the inadequacy of the scope's initial shipping containers delayed slightly full-scale introduction of the scope.

Lineage notwithstanding, if the con-

Few astronomical products have generated as much consumer interest as last year's introduction of 5-inch computer-pointed telescopes by rival manufacturers Celestron and Meade. In less than a decade computerized pointing has moved from being an expensive option on premium telescopes to a feature almost expected as "standard equipment."

PHOTOGRAPHS BY CRAIG MICHAEL UTTER

test between these two telescopes were decided on radically new looks, the NexStar would walk away with the prize. Eschewing the conservative appearance of previous models, this scope features eye-catching futuristic curves — you could imagine George Jetson using one. Stored neatly in the mount's single fork arm is the hand control for the built-in computer that gives the NexStar 5 its Go To capability. While computerized pointing is available in others scopes in the Celestron family, NexStar comes with a street price of $1,199 — well under half the cost of the next-lowest-price model. Low cost coupled with the generally accepted belief that a 5-inch aperture is suitable for "serious" observing makes both these scopes particularly exciting to *Sky & Telescope* readers.

Whatever problems the ETX-125 experienced in the past, none were evident in the new scopes we tested. They arrived packed in cardboard boxes and sandwiched between strategically positioned foam pads, in perfect condition and in collimation. Similarly, the Celestrons survived their journeys double boxed and cocooned in a form-fitting foam bed. The Celestron and Meade shipping containers are not suited to the rigors of repeated use, but both companies offer rugged carrying cases as optional accessories.

The only assembly required for the Celestron is to attach a plastic dovetail bracket for the Star Pointer finder. This sighting device puts a red dot on your naked-eye view of the sky. Once affixed, the finder slides off and on easily, but with enough friction that it won't come off accidentally. Unfortunately, one of the Star Pointers arrived with a dead battery due to a defective switch that couldn't be turned off. Experience has shown that both Celestron and Meade are good about resolving problems like this in a timely manner. One NexStar had a small but noticeable cosmetic defect on the telescope's tube.

Having previously evaluated several 5-inch ETXs, our new unit offered no surprises. Setup involves installing and aligning the 8×25 finder. No tools are needed. Attaching the scope to Meade's standard (model #883) tripod requires a bit of care since the tripod head is smaller than the base of the scope. It is well worth practicing the procedure a few times in a well-lit room before heading out under a dark sky.

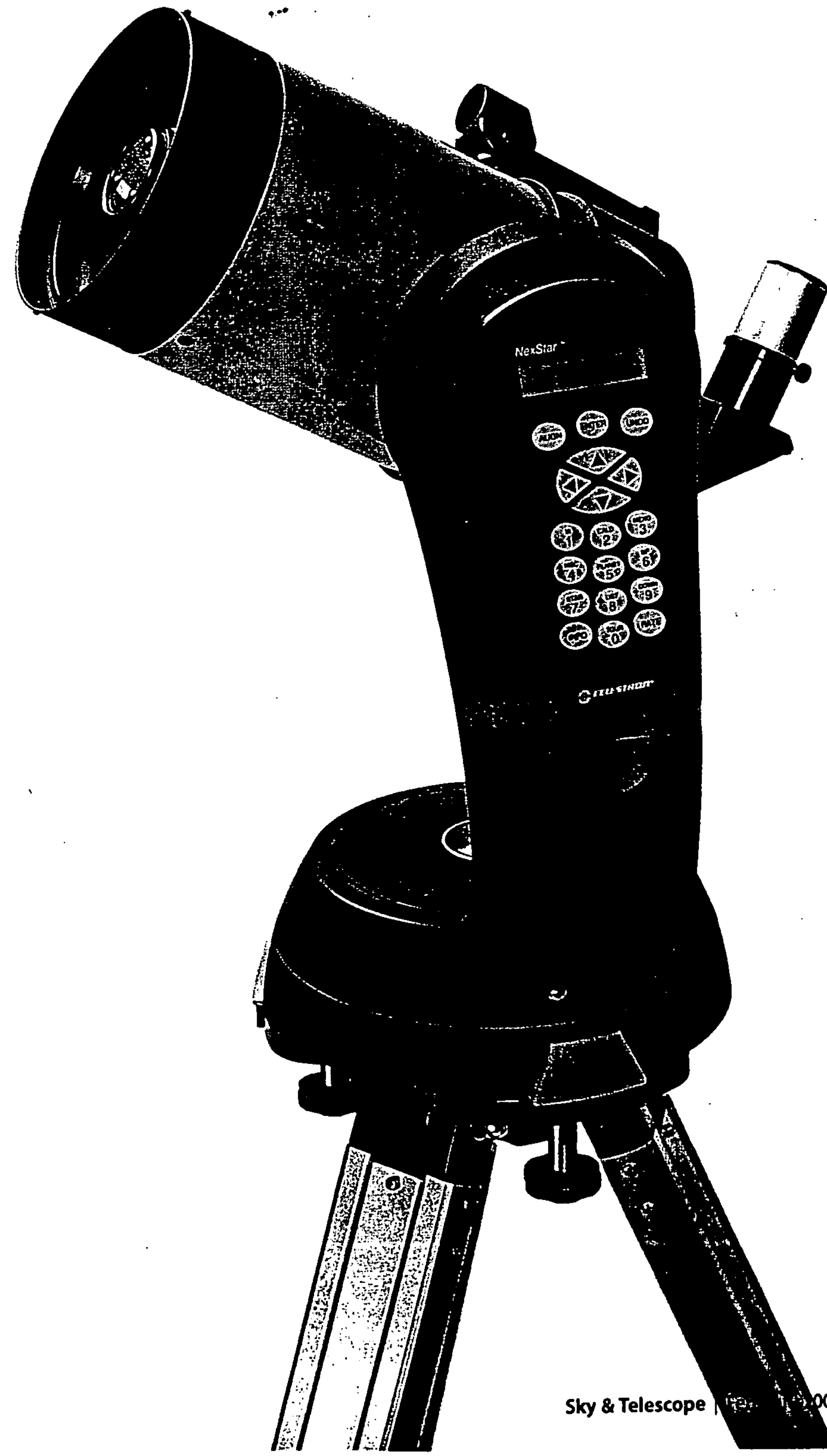
By comparison, mounting the NexStar to its recommended tripod is easy since three big rubber feet on the base of the scope fit into matching recessed sockets on a large plate atop the tripod. You don't have to worry about balancing the scope while securing it to the plate with three large hand knobs.

5-inch Telescopes with Brains

Celestron NexStar 5
Street price: *$1,199 (includes controller)*
Standard tripod: *$199*

Meade ETX-125EC
Street price: *$895 basic telescope*
Autostar controller: *$149*
Standard tripod: *$199.95*
Heavy-duty tripod and wedge: *$349.95*

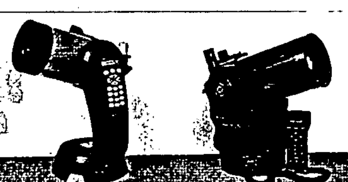
Both scopes are available worldwide through dealers. Visit each company's Web site for a listing — www.celestron.com and www.meade.com.



Both telescopes have lightweight, ergonomically friendly hand controllers with large, easily operated, illuminated buttons and two-line liquid-crystal displays. Autostar's user-adjustable settings make the display's scrolling text more legible in cold weather.

Chasing Stars

The menu structures and the features of the NexStar's internal computer and Meade's optional Autostar controller have a great deal in common. However, our testing did reveal noteworthy differences. Upon powering up the NexStar (we tested software version 2.12.12.6), the scrolling display on the self-illuminated hand control instructs the user to roughly level the optical tube and point it toward north. Since the telescope can be manually moved only in altitude, this procedure typically requires running the motors, which fortunately move the telescope briskly. Next you enter the date, time, your local time zone, latitude, and longitude — only the last two can be recalled from memory if they were stored earlier as an observing location.



Specifications at a Glance

	NexStar 5	ETX-125EC
Weight		
Telescope	17.2 lbs	17.0 lbs
Standard tripod	10.0 lbs	10.0 lbs
Heavy-duty tripod and wedge	—	22.6 lbs
Focal length*	1,350-mm f/10.8	1,675-mm f/13.4
Field of view		
Supplied eyepiece	55′	46′
Maximum possible (1¼″ eyepiece)	71′	57′
Magnification (supplied eyepiece)	54×	64×
Central obstruction (diameter)	9%	39%
Current draw		
Tracking	190 milliamps	100 milliamps
Slewing	750 milliamps	400 milliamps
Slewing speeds		
Maximum	6.0°/second	5.3°/second
Minimum	1.3°/second	1.7°/second
Cool-down time		
30°F change	1½ hrs.	2 hrs.

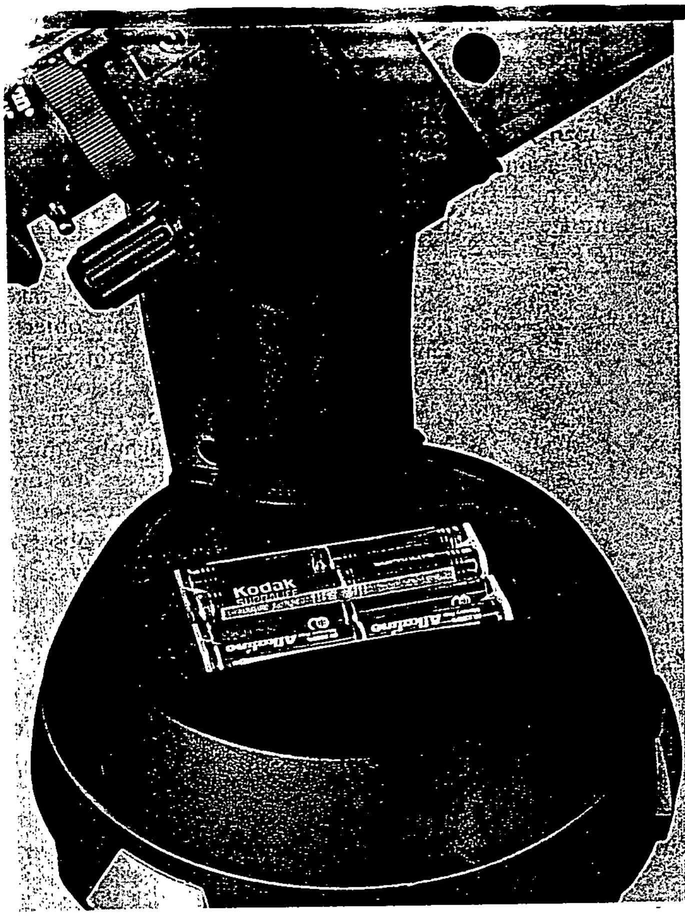
*Focal length varies with the position of the focal point. These values are for the visual focus and are useful for calculating magnifications with eyepieces.

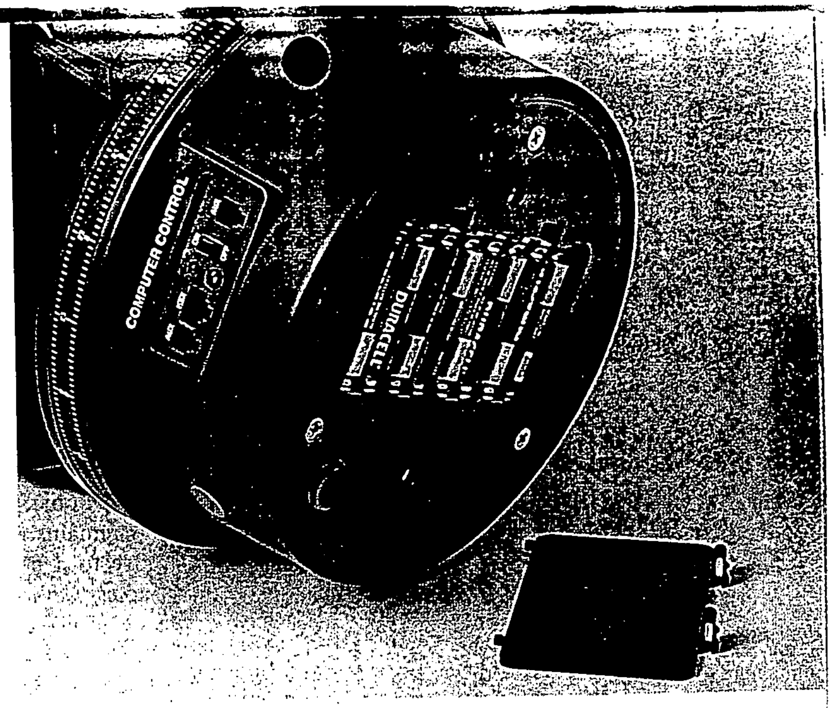
Autostar, on the other hand, remembers more information and simply requires updating the date and time as long as other parameters don't change. It automatically turns on a red "map" light to aid in reading a watch when setting the time. Regardless, the initialization procedure with either scope takes only a minute or two.

Once the preliminary data entry is out of the way, both scopes automatically slew to the first of two alignment stars. The telescopes always choose bright, naked-eye stars (alternates can be selected if the original ones are obscured by trees and the like). After the second star has been sighted, the hand controllers confirm whether or not the alignment was successful. NexStar even flashes an instruction telling you to turn off the Star Pointer because you won't need a finder again that night! You also won't need setting circles, which is why this scope has none.

To test the pointing accuracy of the scopes we ran them through dozens of identical stellar obstacle courses using bright stars scattered across the sky. In each case we called the stars from the respective scope's internal database. To make these tests challenging, the scopes were always made to travel long distances (usually more than halfway across the sky) for each move. Our tests were done with the scopes in altazimuth mode, though both can be operated in polar-aligned mode. But short of a handmade rig, using NexStar in polar mode must await the availability of a suitable wedge.

Putting the ETX-125 through its paces was at times satisfying and at times frustrating. During some sessions the scope gave a perfect score — every star ended up well within the 46-arcminute-diameter field delivered by the supplied 26-mm Plössl eyepiece. On other occasions the scope would struggle to acquire targets. But we learned something very interesting about the ETX — its pointing accuracy is critically dependent on the initial two-star alignment. While we expected that using Autostar's "synchronize" function (which resets the computer to the location of a known object being viewed) would improve pointing accuracy, in practice it often made it worse. Instead, we found it far better to spend the two or three minutes it takes to redo the





Both telescopes operate on eight AA batteries as well as 12-volt external sources (a wall transformer is included with the NexStar). The good news is that NexStar's battery compartment *(left)* is readily accessible under a top-mounted cover; the bad news is that you'll have to use this feature if you plan to observe for a whole night. The ETX's compartment *(above)* is at the bottom of the base.

two-star alignment if the scope was found to have so-so pointing accuracy. After such a realignment the scope would often score 100 percent.

Out of the box, the NexStar has an advantage over the ETX when it comes to target finding. The scope's shorter focal length and supplied 25-mm Plössl eyepiece offer a 55-arcminute field, 11 arcminutes wider than the ETX. So, to ensure a fair comparison in our tests, we equipped the Celestron with a zoom eyepiece precisely set to match the ETX's field of view.

As we launched the NexStar on our first stellar obstacle course, we encountered a vexing problem. To point the ETX, we simply punched in the target star's SAO number, a standard five- or six-digit designation from the Smithsonian Astrophysical Observatory *Star Catalog*. While all these stars were part of NexStar's database, which includes "10,385 selected SAO stars," they can only be accessed with a number that is unique to the NexStar catalog. Lacking a cross-reference, we were stuck unless we manually centered the coordinates.

A call to Celestron the next morning resulted in a cross-reference list being sent by e-mail in the afternoon. The list is now available for downloading from the company's Web site. Once the document is opened in an appropriate program, there are straightforward ways to search for a specific SAO star and identify its access number in NexStar's database. You can also do a manual search on a printed copy of the document, but our printout was almost 300 pages long! Regardless, converting from SAO numbers to Celestron's catalog entries does not make for a user-friendly experience.

This hurdle aside, our pointing tests with the NexStar gave perfect results every time. The scope consistently put the target star in the field of view, usually closer to the center than the edge. We also found that it was practical to use NexStar with its hand controller left mounted on the fork arm. In contrast, it seemed like we were always looking for a place to put the ETX's Autostar controller.

Both telescopes are noisy when slewing but run reasonably quietly when tracking. NexStar is quieter and quicker. For example, swinging between the stars Capella and Fomalhaut took the ETX about 50 seconds, with the final 10 seconds or so spent fine-tuning the position even though the star was visible in the eyepiece. The NexStar accomplished the same maneuver in only 28 seconds.

In addition to faster motors, NexStar has another time-saving feature. While the ETX has mechanical stops to limit internal wires from wrapping up, NexStar is designed differently and can spin in any direction indefinitely. This allows the scope to take the shortest route to any target. The ETX will sometimes take a long route around the whole sky when moving between objects that are relatively close together. NexStar's free-wheeling feature only works when operating on internal batteries — using an external wall transformer adds a wire to the system and requires switching to the "cord-wrap" mode, which functions much like the ETX and occasionally makes long slews to cover short distances.

Speaking of batteries, both scopes are powered by eight AA cells. While this is ideal for casual and spur-of-the-moment observing, it is not particularly economical for heavy use. In tracking mode, NexStar's motors consume nearly twice as much power as those in the ETX and operate only about half as long on a set of batteries. In practice, however, both scopes "failed" well before the batteries became too weak to operate in tracking mode. This is because slewing these scopes places significant demand on the batteries and momentarily drops their voltage. As the batteries weaken with use, this voltage drop eventually reaches a point where the microprocessor "brain" in the scope fails. Exactly when this happens depends on the amount of slewing you do and the ambient temperature. A set of fresh alkaline batteries lasted us about eight hours in the ETX and less

than five in the NexStar. A 12-volt wall transformer is the most economical way to power either scope — one is included with NexStar as standard equipment, while it is an option with the ETX.

Both scopes exhibit extremely smooth, vibration-free tracking even when observing close double stars at magnifications in excess of 500×, which is pushing a 5-inch telescope near its limit.

Databases

NexStar and Autostar feature immense databases brimming with all kinds of objects including the NGC, Messier, and Caldwell deep-sky catalogs, plus listings of various other targets — many more than a 5-inch scope can show even under the best skies. NexStar can access many of these objects with fewer button presses than are required with Autostar. If, for example, you want to view the star cluster M38 with NexStar, you simply press the M (for Messier) button and then enter 038. To accomplish the same thing with Autostar, you have to scroll through menus to choose Objects, then Deep-Sky, then Messier before entering 38. Locating successive M objects is less involved, since Autostar remains in a given catalog until you move to a new one. NexStar offers direct-access keys for the planets as well as Messier, Caldwell, and NGC catalogs.

At the press of a button, both scopes offer descriptive information on popular objects in their catalogs, but in most cases Autostar's descriptions were far more detailed, albeit with sometimes cryptic abbreviations. Autostar proved superior in little niceties, such as being able to vary the brightness of the display or the scroll rate of the text, as well as many extra, but occasionally esoteric, menu items. NexStar's display is rendered visible by backlighting that can only be toggled on and off (and you need a flashlight to read the commands to turn it on once it's off). Also, NexStar's fixed-rate scrolling text became unreadable when the liquid-crystal display grew increasingly sluggish as the temperature dropped below the freezing mark.

The early versions of NexStar we tested did not include the Moon in the database of objects, but it has since been added. This raises an interesting difference between the scopes. Autostar is designed for easy updating of its internal software and catalogs, using either files downloaded from Meade's Web site or "cloned" from another Autostar. NexStar cannot be updated by the user. Which is better? Those on Meade's side of the debate proclaim updating as a great way to fix bugs. We agree, but there's also truth in the arguments of Celestron fans who point out that so far NexStar has no significant bugs that need fixing.

Both scopes offer guided "tours" for those who are new to the sky and who don't know what objects are interesting to view. The Autostar tours were far better. With NexStar you enter the month and find yourself inserted into the appropriate location on a list of 78 objects, including such dubious choices as the visually elusive Horsehead Nebula and the expansive Hyades cluster, which will overspill the field of view. It doesn't take long to exhaust the appropriate objects and venture into a part of NexStar's list containing targets that are below the horizon — which the scope will cheerfully point to. While this might be amusing for experienced sky watchers, it's sure to puzzle beginners. Autostar's tours, however, are tailor-made to the observer's date, time, and location. They start with the Moon and planets and move on to showpiece deep-sky objects, most having accompanying descriptions that can be scrolled across Autostar's display. The list is automatically filtered to include only objects currently visible.

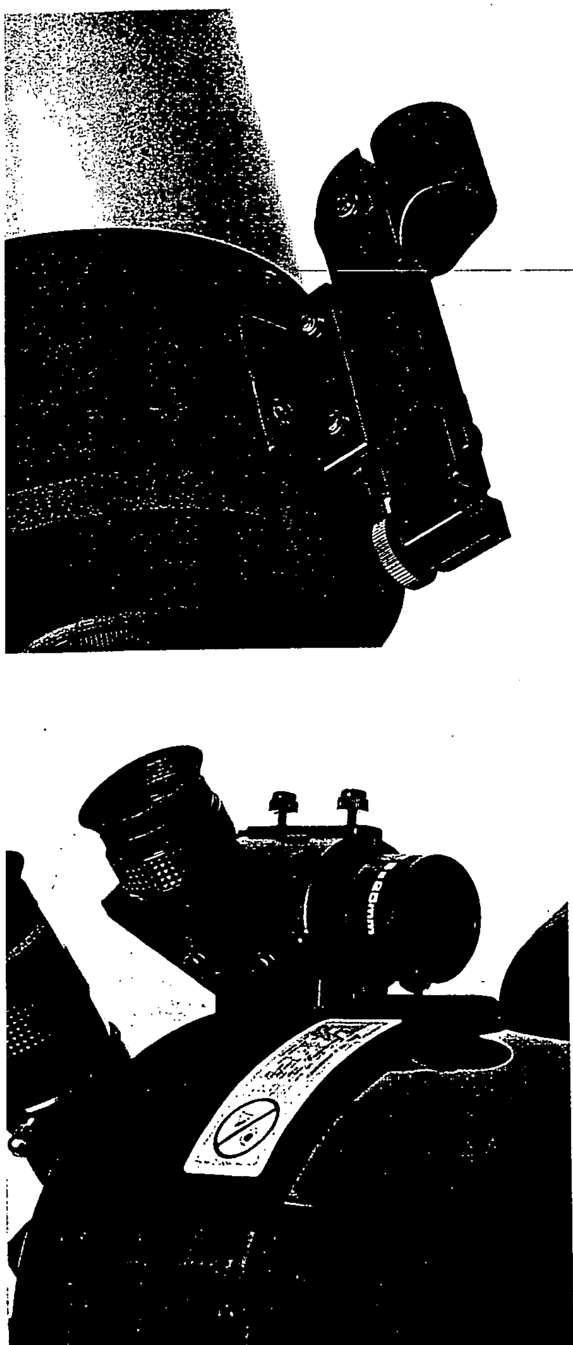
Finders

As mentioned earlier, NexStar is equipped with a zero-power sighting device that is ideal for initially aligning the scope on bright stars. It is an intuitively simple device, which is one reason the same technology has been applied to high-tech gun sites. The ETX has an 8×25 right-angle finder with a right-side-up, mirror-reversed view and a helical-focusing eyepiece. Its non-illuminated cross hairs are thick enough to obscure stars, but this thickness helps render them visible in all but the very darkest sky. The finder's 8° field has poor off-axis images.

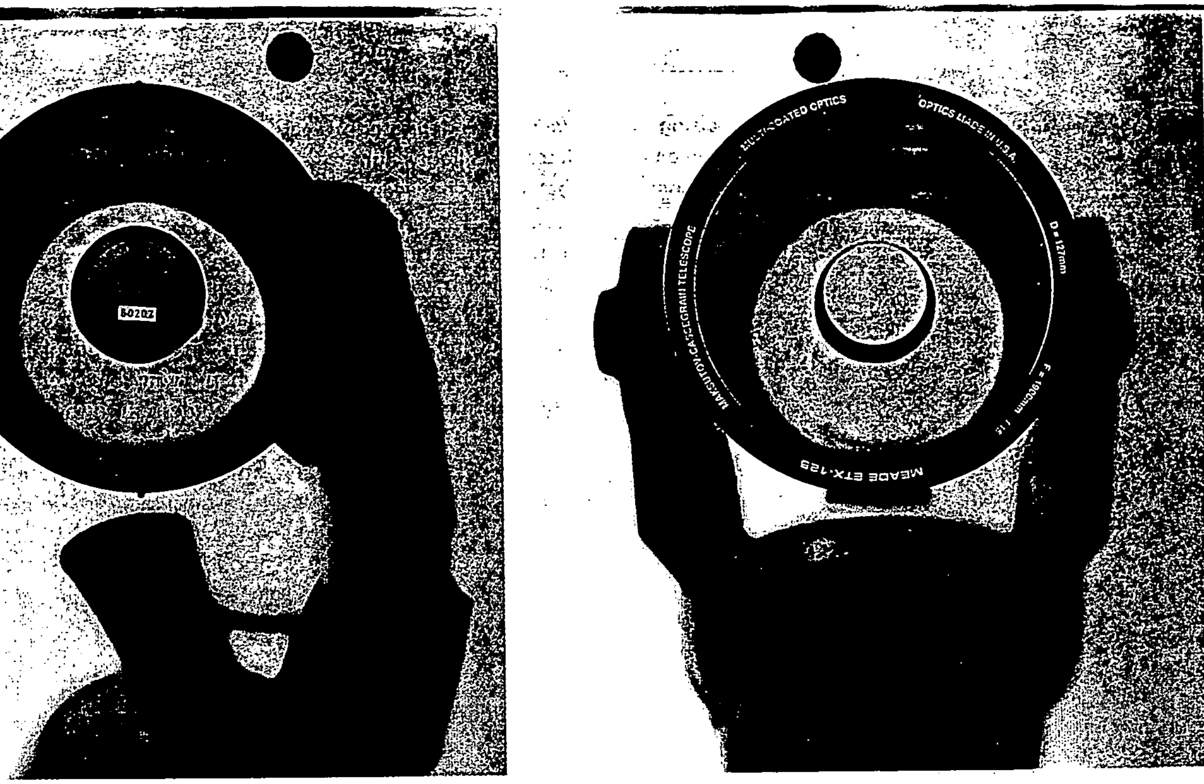
Which finder is better? The answer depends on how you spin it. NexStar's easily mastered Star Pointer with no inherent shortcomings may sound better to some people than ETX's right-angle finder with mediocre optics. But if you argue that a finder's job is to accurately place targets in the main telescope's field, especially ones fainter than can be seen with the naked eye, then Meade is the winner.

Optics

A quick look at an out-of-focus star image in a high-power eyepiece will tell if a scope is optically collimated. Accurate collimating is a necessity for achieving the maximum performance with any telescope, especially NexStar's Schmidt-Cassegrain optical system. Both ETXs arrived in excellent collimation, which was expected



NexStar's zero-power Star Pointer *(top)* is intuitively simple to use and excellent for initializing the telescope's computerized pointing system. The ETX's 8×25 finder *(bottom)* gives a mirror-reversed image and can accurately center on objects fainter than can be seen with the naked eye.



NexStar's Schmidt-Cassegrain optics (*left*) and the ETX-125EC's Maksutov design have central obstructions that are 39½ percent of the aperture's diameter as measured at the focal plane. While pundits often dismiss scopes with obstructions larger than 25 percent as being unsuited for critical planetary observing, we found the views of Jupiter and Saturn to be very satisfying.

since they cannot be adjusted by the user. The NexStars, however, arrived out of collimation. Aided by thorough instructions found in the manual, we easily adjusted each scope using the supplied Allen wrench. Every Schmidt-Cassegrain user should learn this process, which has been likened to the tuning of a musical instrument. Many telescopes capable of delivering fine images have suffered because the optics were not properly collimated.

Nevertheless, even when collimated, one NexStar produced substandard images. Initially we suspected that part of the problem was due to the supplied prism-type star diagonal. Close inspection revealed its eyepiece holder was not centered on the optical axis. This was not a fluke. Both diagonals with the NexStars as well as another with a recently obtained Celestron telescope were made the same way. The problem also surfaced in a diagonal supplied with a Vixen refractor. These diagonals are mass-produced in the Far East, and it's anyone's guess how many with this problem have reached consumers. Fortunately it's not a fatal flaw, but why did it seem to affect one NexStar more than the other? The answer came as a surprise.

After we replaced the standard-issue diagonal with a high-quality unit from Lumicon, there was still a difference in image quality between the NexStars, and we soon classified the scope purchased randomly as having acceptable, but rather mediocre, optics. It wasn't until we began bench-testing that we discovered this scope's secondary mirror wasn't precisely centered on the optical axis because of an undersized corrector plate that could slide laterally in its cell by as much as 4 mm. Since an off-center secondary degrades image quality, this was a startling discovery. Further inspection showed that both NexStars had undersized correctors, but only one had been jostled off center, probably during shipping. A call to Celestron confirmed that the problem was discovered only after some of the initial NexStars had shipped, and that it had since been corrected.

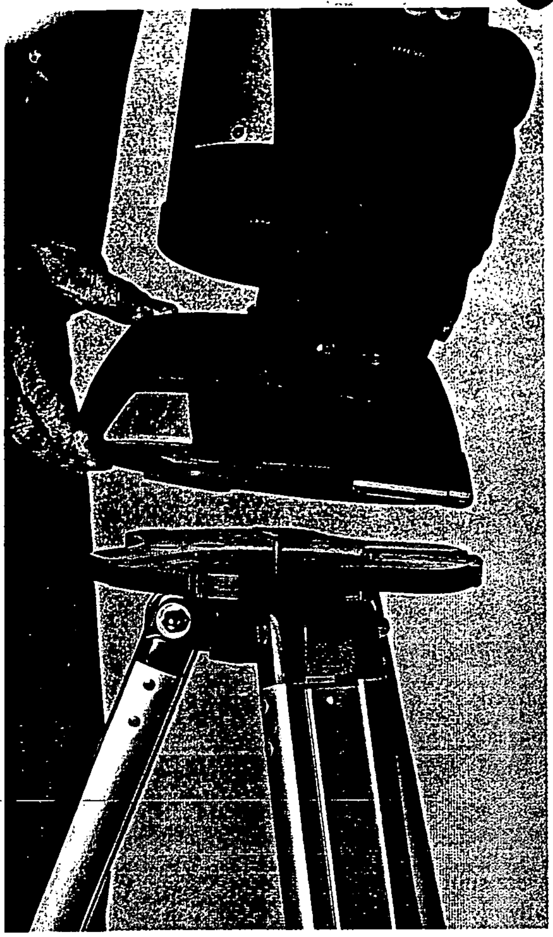
Centering the corrector of the NexStar branded "mediocre" elevated the optics to equal status with its twin, and both now deliver fine images. Critical star tests revealed just a trace of undercorrected spherical aberration in diffraction patterns viewed inside and outside of focus.

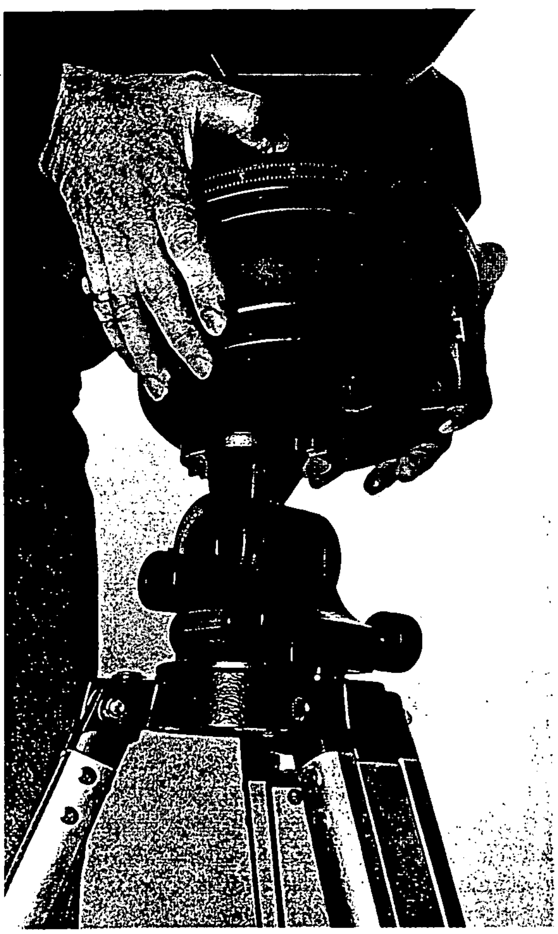
The optics in both ETXs were very good and revealed essentially identical diffraction patterns inside and outside of focus. All four scopes produced tight, clean star images that came to critical focus with no ambiguity even at magnifications above 100×. In side-by-side comparisons of the ETX and NexStar we independently rated the high-power images in the ETX as better, but the differences were subtle. It is difficult imagining that any owner would find fault with the optical quality of the scopes we tested.

The NexStar and ETX focus by moving the primary mirror along a central baffle tube. A certain amount of image shift often results from this design, since the mirror tilts slightly as you reverse the direction you're turning the focus knob. The NexStars showed absolutely no image shift, while the ETXs had only a very slight amount. One ETX had a dead spot where nothing would happen for a fraction of a turn when the direction of the focus knob was reversed. This was most annoying when trying to achieve critical focus at high magnifications.

Both telescopes have central obstructions that measure 39½ percent of the aperture's diameter. While optical experts agree that an obstruction this large precludes any instrument from achieving optimal performance when it comes to revealing subtle planetary detail, it does not mean these scopes can't produce *pleasing* views. Indeed, both scopes delivered very enjoyable views of Jupiter and Saturn when the atmospheric seeing was steady. These are really general-purpose scopes, not instruments designed for planetary fanatics.

For deep-sky observing, NexStar's ability to show a wider field of view came in





Setting NexStar *(left)* on its dedicated tripod is a straightforward task. Placing the ETX *(bottom)* on the small top of its lightweight tripod requires a bit more care due in part to the steel stiffening plate that mounts between the tripod and scope.

handy. Although the maximum diameter of the true field afforded by these scopes differs by only 14 arcminutes, it does allow the NexStar to take in a single gulp of sky with 55 percent greater area. This helps when viewing sprawling star clusters, such as the Double Cluster in Perseus or the outer expanse of the Orion Nebula. Of course, to get the widest fields of view requires a different eyepiece than was supplied with either telescope.

The Mount

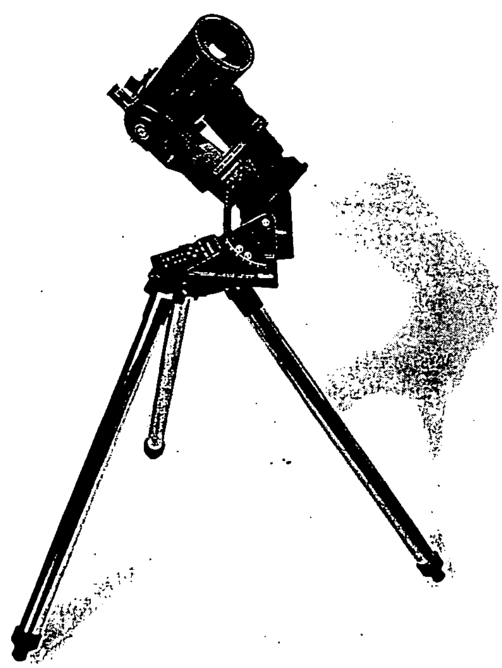
The NexStar 5 is the winner when it comes to having a solid mount. Coupled with its dedicated field tripod (a $199 option), the telescope is very stable. Vibrations damped out in about a second, making focusing at high magnification a jiggle-free pleasure.

Attached to its standard tripod (a $199.95 option), the ETX had a much longer damping time. This varied according to how the telescope was oriented and in some configurations exceeded five seconds. It made focusing at high magnification a challenge. One solution is the optional $349.95 Advanced Field Tripod #877 recently introduced for the ETX. It includes an adapter, wedge, and the fixed-height tripod originally designed for the 8-inch LX10 Schmidt-Cassegrain telescope. Used with the ETX in altazimuth mode, it reduced the damping time to a little more than a second. The adapter is available separately for $69.95 and allows the ETX to attach to any tripod or wedge made for Meade's Schmidt-Cassegrain telescopes.

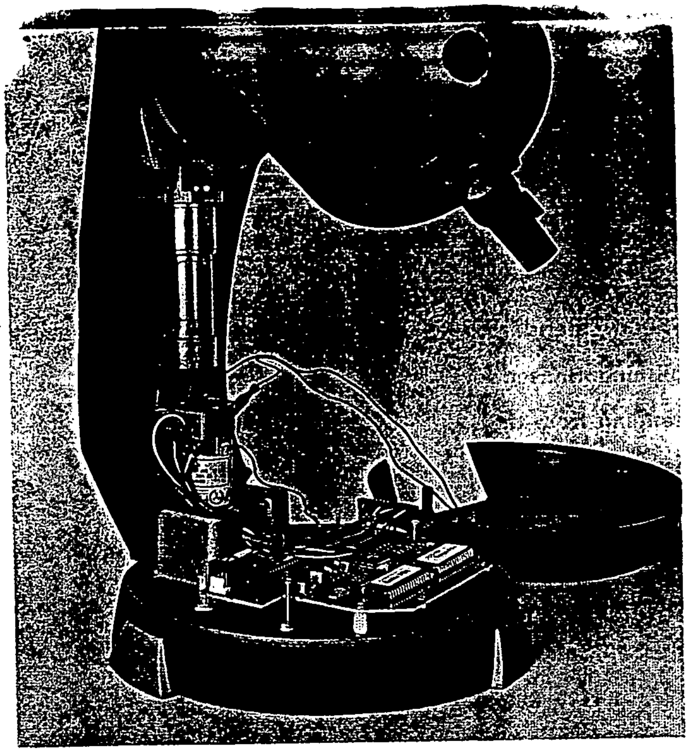
The drives on both telescopes performed very well when observing with magnifications of 150× and less, which are typically used for deep-sky and general viewing. But, just as with optical evaluations, high-magnification observing taxes the qualities of any telescope. In this regard neither scope scored a knockout victory over the other. NexStar's solid mount coupled with a focusing knob that operated with a delicate touch was certainly an advantage. But the scope had about ½° of backlash in the altitude drive. The drive has electronic backlash compensation, but invoking it caused one of the hand controller's altitude buttons to have an annoying delay when pressed. This made it difficult to "jog" the scope when trying to center a target.

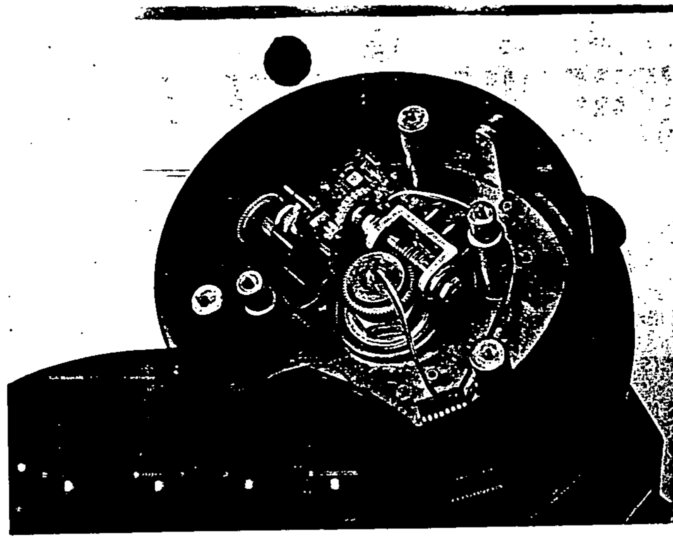
In addition to the focusing jitters mentioned above, the ETX required a fair amount of drive-button finessing to keep an object centered in a high-power field when the scope was used in altazimuth mode. This, however, was not required when the scope was tracking in the polar-aligned mode.

One advantage frequently credited to the Schmidt-Cassegrain design found in NexStar is short cool-down time. Since neither it nor the ETX's Maksutov design is capable of delivering the best possible image until the optics have acclimated to the ambient air temperature, this is an important consideration. Our tests showed that the NexStar did acclimate about 25 percent faster than the ETX when moving from a 70° Fahrenheit house to 40° night air. While both scopes needed about an hour before giving acceptable images, out-of-focus stars still showed a heat plume rising from the central baffle tube for another half hour in the NexStar and nearly an hour in the ETX.



Right: The ETX's optional heavy-duty tripod includes a wedge for polar-aligned tracking. This system's stability offers significant advantages for high-magnification viewing. A mounting adapter is available separately and permits the ETX to be used with the wedge and tripod designed for any Meade 12-inch and smaller Schmidt-Cassegrain telescope.





The structural parts of NexStar's mount *(left)* are metal, and the scope is driven by a pair of high-quality Pittman gear-head motors. The structural parts of the ETX mount *(above)* are a combination of metal and plastic castings, and the motor drives use custom gear trains. While the mounts proved equally accurate in pointing tests, NexStar's performance was more consistent.

And the Winner Is . . .

The debate over Meade and Celestron is much like that surrounding Coke and Pepsi or Ford and Chevy — there is no clear-cut winner or loser. Both telescopes have pluses and minuses. Which one you see as better will depend on personal preferences and perhaps brand loyalty. Out of the box, NexStar was easier to master than the ETX. Its pointing accuracy, while no better than the ETX, was more consistent. The ETX, on the other hand, uses the Autostar controller, which offers considerably more features than NexStar. At the eyepiece the differences were subtle at best, but the ETX took the nod for planetary observing, while NexStar got it for deep-sky work.

No matter how you look at it, both these telescopes offer a lot of performance in an attractively priced package. And, judging from consumer reaction, they are proving that computer-pointed instruments are the way of the future.

Interoffice E-Chat: Dennis and Gary Choose

Instant Message

File Edit View People

GARY: *Should we pick a winner? If I had to recommend one of these scopes to a friend, I'd pick the Celestron — it gave the most satisfying out-of-the-box experience.*

DENNIS: True. Originally I thought that my first night with NexStar went so smoothly because of my experience with Autostar, but in retrospect the Celestron is very easy to master. Nevertheless, isn't learning to operate any telescope just that — a learning process? Once you get the hang of the ETX there's an awful lot it can do. Autostar is by far the most sophisticated controller for any telescope.

GARY: *But as a die-hard planetary observer, I don't need Go To for locating planets, and I'm not thrilled by a small, highly obstructed scope.*

DENNIS: I think the obstruction issue is overblown. You have to be a planet fanatic to find fault with these scopes. There wasn't that much difference between them and my 6-inch Mak/Newtonian with its small obstruction. The 6-inch was double the cost of even the NexStar, weighs more than twice as much, and doesn't have Go To — that's a high price for slightly better planetary views.

GARY: *I quite agree. For the general observer who bounces from the deep sky to double stars and casual looks at the Moon and planets, either scope works out nicely. I think anyone considering a 4-inch refractor should seriously consider one of these. However, there are always observing specialists who will whine about general-purpose scopes. This begs the question about photography.*

Instant Message

File Edit View People

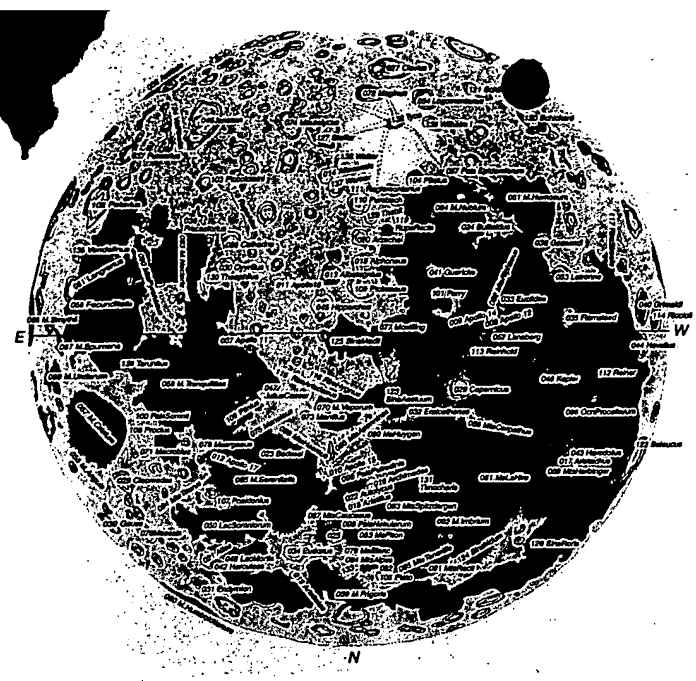
DENNIS: You proved in the November review that the ETX can take lunar snapshots, and the NexStar's optics have an imaging track record going back nearly 30 years. Both are baffled for daylight photography. In polar-aligned mode both mounts should be okay for wide-angle piggyback work, but neither company offers a camera bracket. The NexStar's mount will probably handle a heavier load, but that's moot until a wedge is available. I wouldn't pick either for long, guided exposures through the scope. :-(

GARY: *I guess it all really boils down to telling readers to ask themselves what they want from a telescope. I see both scopes offering plenty of observing opportunity, particularly for beginners. But I think before people plunk down their money they need to ask how important that Go To feature is. The same money could buy a basic 8-inch Schmidt-Cassegrain from Celestron or Meade with cash left over for extra eyepieces. You'd trade Go To and some portability for a larger aperture, and that's always a plus.*

So, are you going to pick a winner?

DENNIS: What? Pick one and tick off everyone who likes the other! <g> Seriously, neither scope scored a knockout victory over the other in any of our tests. If I wanted the best, I'd flip a coin to pick the optics, stick the winner on the NexStar base, mount it on the Meade heavy-duty tripod, and drive it with Autostar. That's my choice, and it ought to tick off everyone.

GARY: *We can call it the "NEXT 125!"*



Unique to SkySensor is its database of 138 surface features on the Moon, including Apollo landing sites, shown here in a map from the instruction manual. Locating lunar features requires first precisely aligning on one of those features or on the Moon's center. Even so, SkySensor located lunar features only roughly.

Sensor can warn you when a satellite rises above the horizon. Scroll to that satellite's page, hit Go To, and the mount slews to the satellite and begins tracking it at high speed. At least in theory. When I tested this with several passes of the International Space Station and Mir, SkySensor never placed the satellite in the main telescope eyepiece. Close, within the finder, but not in the main optics. Even a slight error in entering your site's latitude and longitude or the current time will make a big difference in finding a satellite. Also, you must have the latest orbital elements, which, for the decaying Mir, are constantly changing.

In one passage of Mir I was able to jockey the slow-motion controls on the fly to center the Russian space station in the eyepiece of the main telescope. Once I did that, the mount tracked it fine as it flew away to the east.

One catch: if the mount slews up from the west, when it reaches the meridian it stops and waits for you to command it to flip itself to the other half of the sky, where it will resume tracking the satellite to the east. This "about face" is unavoidable with a German equatorial mount, but it does diminish the satellite tracking feature — just when the satellite is closest you lose sight of it for the 30 seconds it takes the mount to flip. Also, it was under high-speed tracking that I did notice some image jitter, making it that much harder to make out the shape of an orbiting object such as Mir.

Shutting down SkySensor is also novel. Unlike most other computerized scopes, there is no preferred parking position. Just turn off the controller. It remembers where the telescope was last pointed. As long as the mount or telescope tube is not moved, you can switch on the controller at a later time and bypass the alignment routine. This worked well, allowing me to find targets in a daytime sky with ease and accuracy.

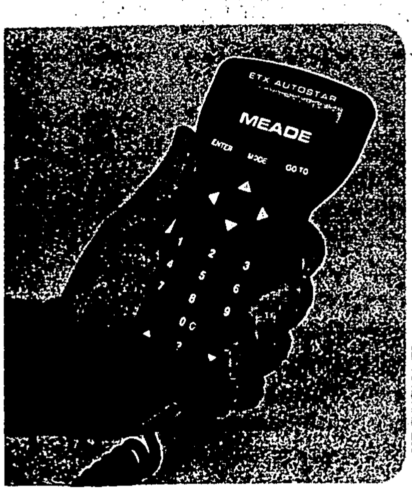
SkySensor's hierarchy of menus is powerful yet easy to navigate. The displays provide detailed object data (though no scrolling text descriptions). SkySensor lacks well-crafted "tours" of the best telescope targets selected by experienced observers. Like some other Go To telescopes, SkySensor's tours are little more than computer-generated listings of bright objects. I've always felt that grouping objects by constellation is a friendly way to view the sky, but the blind reliance of most Go To computers on databases arranged by right ascension or catalog number precludes this.

Far outweighing any criticisms is the

And the Winner Is . . .

By Dennis di Cicco

Last December we presented our annual editors' roundup of 25 hot products introduced during the previous 12 months. And for the first time we invited readers to vote for the item they felt was the year's hottest product, either from our selection or a nomination of their own. The results were gratifying since every item on our list received votes, confirming that at least some readers thought each of our picks was the best new product. It was also gratifying because there were very few nominations, suggesting we didn't miss anything big, particularly in foreign markets, where it is more challenging to keep abreast of developments.

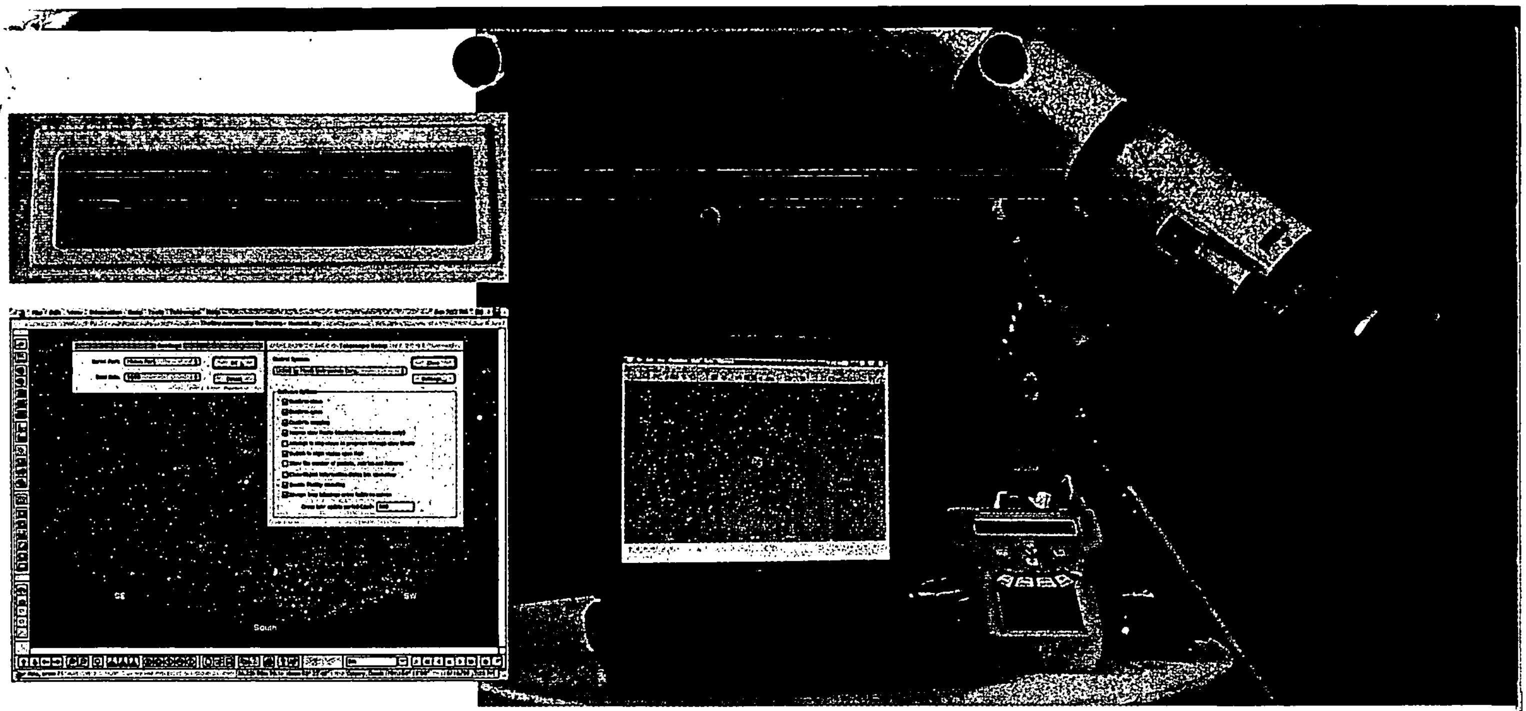


S&T: CHUCK BAKER

More about the write-in nominations in a moment, but let's start with the top vote getter — computer-pointed telescopes. From the outset we knew there was huge interest in Meade's Autostar and Celestron's NexStar 5, which is one reason that our review of them was the cover story in the February issue. But it still surprised us that four out of every 10 votes cast were for one of these products. For the record, Autostar garnered more than 22 percent of the vote, while NexStar 5 captured almost 18 percent. It was a real horse race: as the weekly vote totals arrived, some gave Autostar the lead while others had NexStar in front. Furthermore, the vote may be even closer than the final numbers suggest. It's clear that some people cast their vote for Autostar coupled with Meade's entry-level DS telescopes, while others considered its use with the ETX-90EC or the larger ETX-125EC. Thus, the *single* computer-controlled telescope getting the most votes may have been NexStar 5.

When computerized telescopes entered the market there were amateurs who dismissed them as superfluous gadgetry, much the way some people looked upon the automobile at the beginning of the 20th century. It's now clear that, like the automobile, computerized telescopes are winning the popularity poll.

Autostar and NexStar 5 so dominated the voting that together they amassed six times more votes than the third-place product — Tele Vue's Nagler Type 5 eyepiece. The fact that a $600 eye-



overriding fact that SkySensor worked reliably. The hardware is well made and the software is robust — never once did I have the hand controller freeze up, crash, or display cryptic error messages. For the most part, I found SkySensor remarkably frustration-free.

In my experience the stability and accurate tracking of Vixen's mounts rival models costing twice the price, even without Go To functions. Yet they are light and portable. The GP is the best mount I've seen in the $1,000 price league. Orion sells it for $699 plus $400 for a pair of conventional motors and associated controller. Instead of these motors, for $1,039 you can get the SkySensor package with all its high-tech functions. Thus, for less than $1,750 you can have a versatile Go To mount that has few rivals on the market. Vixen has produced a strong contender in the Go To sweepstakes.

As advertised, operation of SkySensor under control of a laptop running Software Bisque's *TheSky* software proved trouble-free. While the reviewer did not try controlling SkySensor with other software packages, the controller can be set to accept either Meade's LX200 or Celestron's Ultima 2000 commands. This increases its compatibility since astronomy programs, including the latest version of *TheSky* used for this review, do not have internal settings specifically for SkySensor.

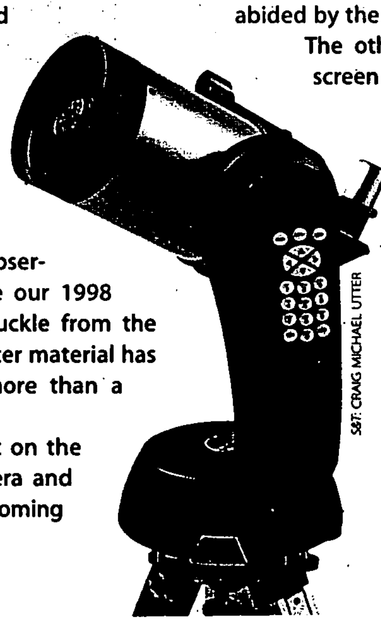
ALAN DYER *is a contributing editor for* Sky & Telescope *and author of* Pathfinders: Space, *a new children's book from* Reader's Digest.

piece intended primarily for deep-sky observing placed third in our poll was a bit of a surprise, and it suggests that there are a lot of very serious deep-sky observers out there. Bolstering that belief were the next four top vote getters, whose exact ordering is obscured by statistical uncertainty in the poll. They were our own *Sky Atlas 2000.0*, Willmann-Bell's two-volume *Night Sky Observer's Guide*, Tele Vue's Radian eyepieces, and Orion's SkyQuest Dobsonian telescopes.

While write-in nominations were few, they were interesting. Many were for products not introduced within the time frame of our 1999 compilation, which was expected since it often takes detective work to determine when a product debuted. Some, such as Collins's image-intensified I[3] Piece and Kendrick's portable tent observatory were actually available in time to make our 1998 hot-product listing. We did, however, get a chuckle from the nomination of Tuthill's Solar Skreen, since this filter material has been admirably serving solar observers for more than a quarter century!

Other nominations were for products not yet on the market. Examples include SBIG's STV CCD camera and several products that, while advertised, were just coming to market as our 1999 deadline passed. They'll be considered in our next roundup.

There were two write-ins mentioned enough times to make us take note. One was the Italian image-processing software *Astroart*. While I've used (and like) this program, it was clear that it received many of its votes from several readers who abided by the old political adage "vote early and often."



S&T: CRAIG MICHAEL UTTER

The other major write-in was already on our radar screen — Discovery Telescopes' line of low-cost equatorial reflectors. Sporting above-average features and an extremely attractive price, the 8-inch model made our initial hot-product selection and we requested one from the manufacturer for a hands-on check before assembling our final list. Because an important design modification was not scheduled before our deadline, the scope just missed the final cut. Nevertheless, we, and many readers, recognize this instrument as a great dollar value.

We're all looking forward to what 2000 has in store for amateurs. If last year was a reliable barometer, 2000 will be a very good year.

Meade's ETX-125EC — A First Look

This 5-inch Maksutov telescope starts where the original 3.5-inch left off. | **By Gary Seronik**

S&T TEST REPORT

AMID THE CLAMOR AND EXCITEment surrounding the release of Meade's ETX-90EC earlier this year one could hear voices saying, "That's nice — but it *is* only a 90-millimeter scope!" For those seeking more light grasp, Meade has responded with a 5-inch version of its groundbreaking low-cost Maksutov-Cassegrain. But could this big brother ETX match the superb optics and Go To accuracy of its smaller sibling? To find out, *S&T* obtained two early production units directly from Meade. Here's what we found.

Go To Take Two

Like the 90-mm ETX, the 125EC comes with motorized tracking and slewing capability and a basic hand controller as standard equipment. For the optional Go To capability, both ETXs utilize the same Autostar controller (see the May issue, page 61, for a description of features). However, because the 5-inch ETX has a longer focal length and thus a smaller field of view, identical electronics do not guarantee identical performance. For Autostar to place objects in the eyepiece of the 5-inch scope, the system's pointing accuracy would have to be nearly twice as good as with the original ETX.

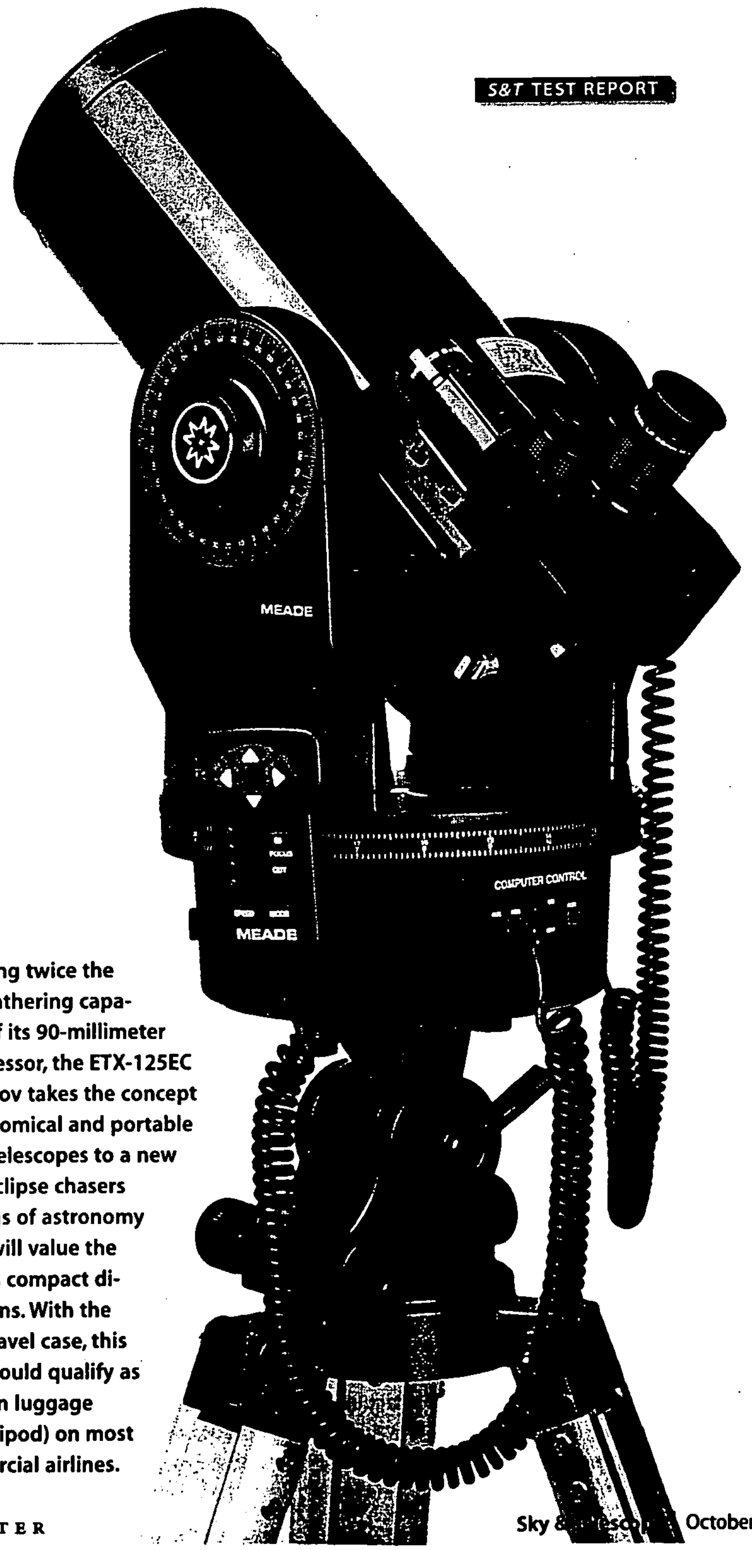
To evaluate the 125EC's Go To accuracy, I selected 10 stars distributed evenly over the sky and had the scope find them one at a time. To make this a worst-case test, I made the scope swing across at

ETX-125EC Maksutov-Cassegrain

5-inch Maksutov-Cassegrain telescope with motor drives and optional computer controller

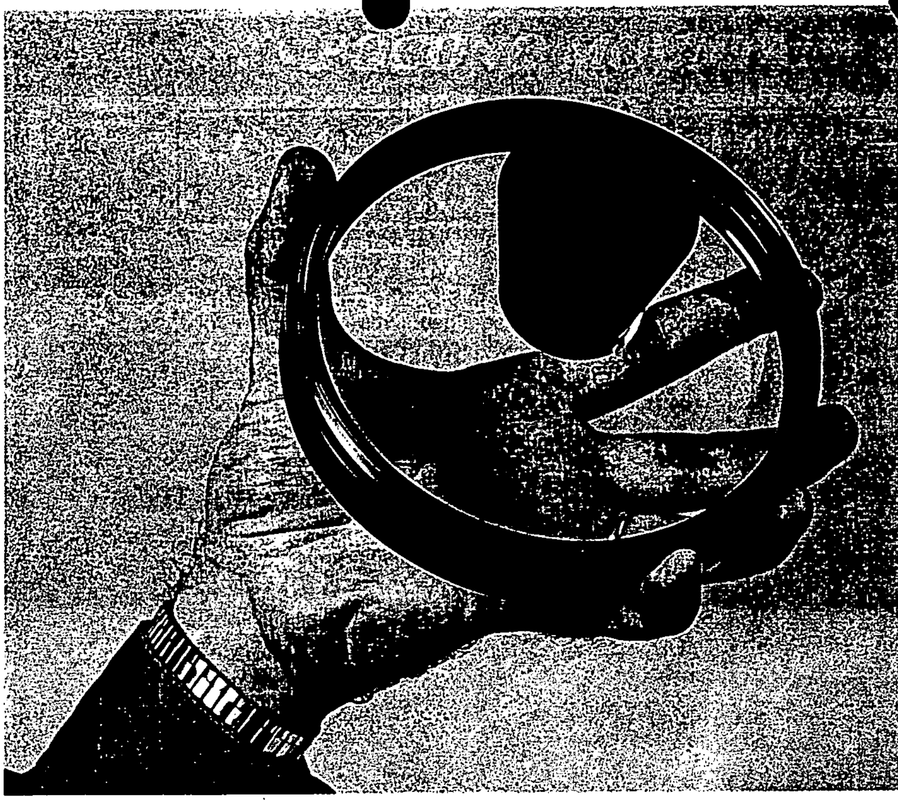
Price: $[illegible] basic telescope
$[illegible] Autostar controller
$[illegible] field tripod

Meade Instruments Corporation
[illegible] dealers [illegible]
www.meade.com



Featuring twice the light-gathering capability of its 90-millimeter predecessor, the ETX-125EC Maksutov takes the concept of economical and portable Go To telescopes to a new level. Eclipse chasers and fans of astronomy travel will value the 125EC's compact dimensions. With the right travel case, this scope could qualify as carry-on luggage (sans tripod) on most commercial airlines.

PHOTOGRAPHS BY CRAIG MICHAEL UTTER



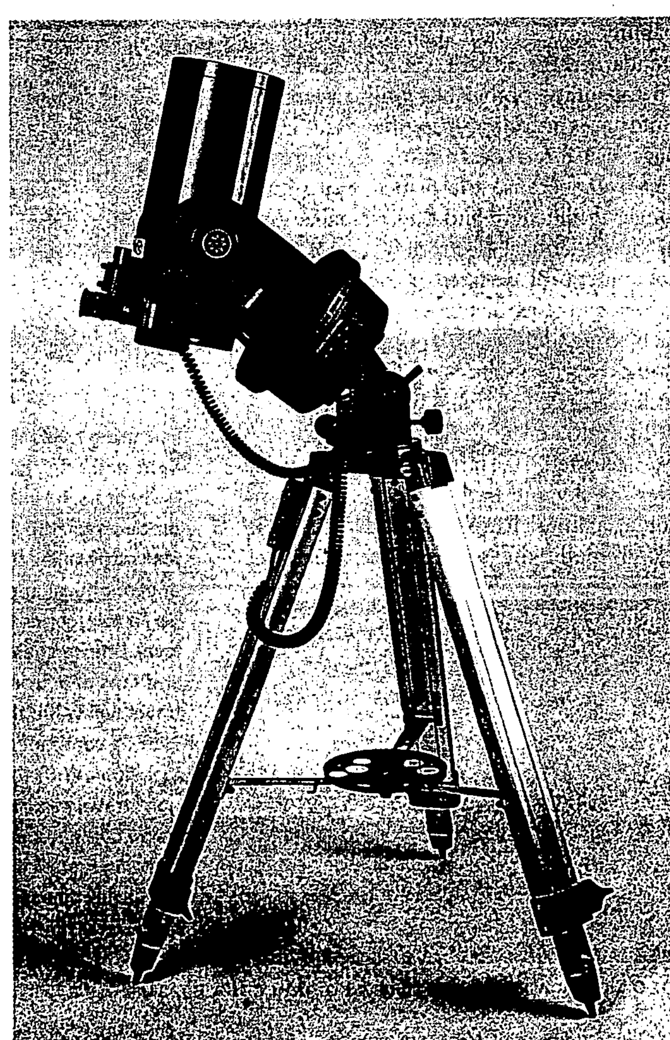
Although necessary to prevent stray light from reaching the focal plane, the flared secondary baffle shown here increases the size of the ETX-125EC's central obstruction to nearly 40 percent. Instruments optimized for high-resolution planetary views should have central obstructions less than 25 percent of the scope's aperture.

least half the sky to go from one star to the next. For example, after I sighted Antares, the next star on my list was Gamma (γ) Cassiopeiae, and then Spica, forcing the scope to make long slews.

So how did the new ETX do? Using the supplied 26-mm Plössl eyepiece, Autostar put the target star into the 45-arcminute field of view 87 percent of the time. Usually the star was closer to the edge than to the center. (This is reasonable since only ¼ of the field of view's area lies inside the center half of the field's radius.) This percentage held up regardless of whether the scope was used in polar or altazimuth tracking modes. And when Autostar missed, it wasn't by much. In fact, using a 35-mm Plössl that produced a 1° field (the maximum possible with the 125EC), the test star was always in the field of view.

We mounted our test units on the model #883 Deluxe Field Tripod — the same tripod recommended for the lightweight ETX-90. To improve stability, the 125EC comes with a ⅛-inch-thick metal plate designed to fit between the tripod head and telescope base. The vibration-damping time for this setup depended to some extent on the orientation of the tube and ranged from 3½ to 4½ seconds for

Meade offers an optional electric focuser ($119.95) designed specifically for the 125EC. This user-installed option effectively eliminates the jiggles introduced by manually focusing the telescope.



Weighing in at nearly 19 pounds, the 125EC demands care when being attached to its field tripod. Once secured with two hand bolts, the resulting assembly is quite top-heavy. Particular care must be taken when the scope is configured for use in the polar mode because much of the telescope's mass is offset from the center of the tripod.

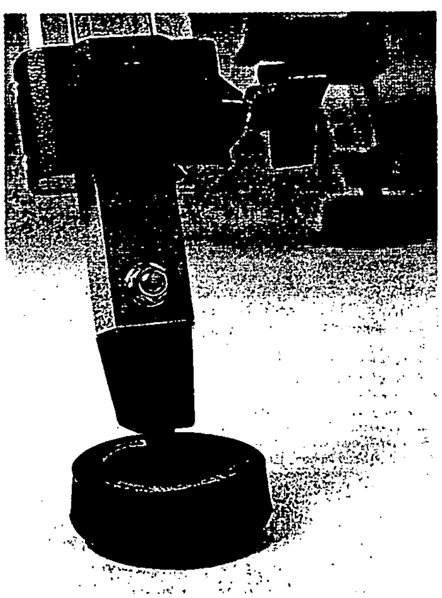
both altazimuth and polar modes. This proved to be most troublesome when focusing. A set of Celestron Anti-Vibration pads placed under the tripod legs cut the damping time by more than half.

Optics

The optics of the 90-mm ETX have drawn considerable praise for their quality and consistency. Will the 5-inch model match this high standard? If the two samples we received from Meade can be taken as reliable indicators, the answer is yes. Careful testing showed that both 125ECs featured excellent optics. Stars at the center of the field focused to sharp points, free of astigmatism or other aberrations. Bright stars were surrounded by a faint halo of scattered light and off-axis star images displayed some coma, suggesting that this Maksutov has a slightly different optical recipe than the 90-mm ETX. Neither problem detracted from the viewing experience.

Maksutov telescopes have acquired a reputation for first-rate planetary views. As a solar-system observer myself, I was curious to see how the 125EC would perform with Mars (which was nearly two months past close approach during the test period) and the Moon. Mars appeared crisply defined though its surface markings proved elusive. Views of the Moon were pleasingly sharp and rich with satisfying detail.

On several nights I set up the ETX next to my home-built 4.2-inch f/6 Newtonian, my favorite "quick-look" instrument. Using the same magnification, I found an obvious difference in performance — the Newtonian showed the Martian surface markings with greater certainty than did the 5-inch Maksutov. The red planet seemed drained of low-contrast detail in the 5-inch view. This is most likely a consequence of the 125EC's large central obstruction — nearly 40 percent the diameter of the aperture. An obstruction this size has the effect of reducing the 5-inch scope's contrast to that of an optically excellent unobstructed 3-inch instrument (see "Rules of Thumb for Planetary Scopes — I," *Sky & Telescope*, July 1993, page 91).



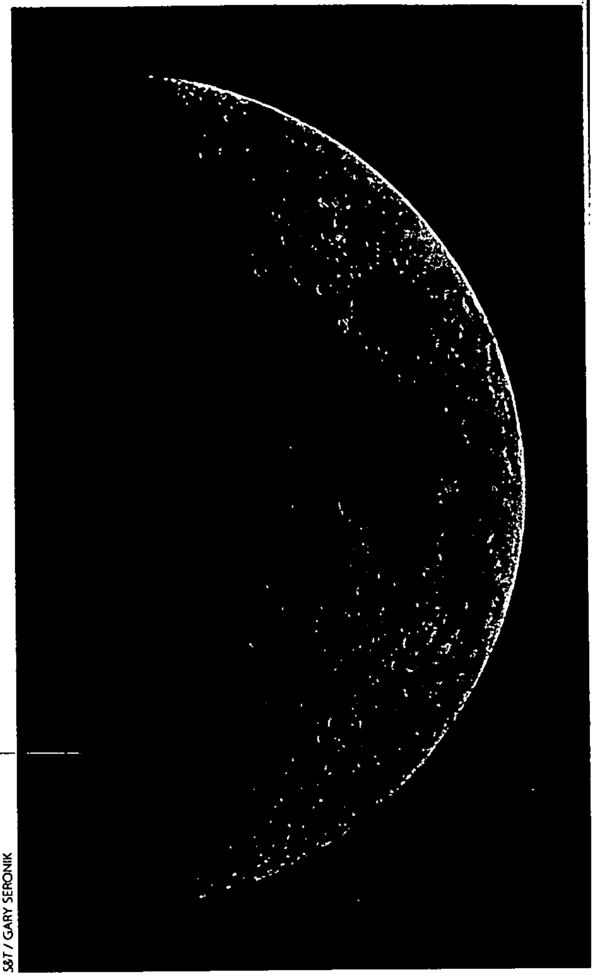
Testing showed that the mount's damping time is cut in half by using a set of Celestron vibration-suppression pads. This accessory should be a high-priority item for anyone considering the ETX-125EC and optional field tripod combination.

Motor vibrations also affect the image. One evening I decided to have a look at the well-known Double Double, Epsilon (ε) Lyrae, high overhead. This pair of pairs features doubles separated by 2.3 and 2.6 arcseconds — easy splits for a 5-inch instrument. To my surprise, the ETX showed only the two main stars (Epsilon^1 and Epsilon^2) despite the steady seeing conditions of a muggy summer night. Puzzled, I switched off the drive, and magically all four stars popped into view. Further investigation revealed that vibration introduced by the altitude motor was the culprit. Indeed, at 100× one could watch stars bloat up and shrink down as the motor drove the scope in altazimuth-tracking mode.

As this review was being readied for press, Meade engineers contacted us to say that they had identified this problem and implemented a fix. See our Web site, www.skypub.com, for an update after we check out a modified scope.

Although the focusing mechanisms worked smoothly on both scopes, one exhibited approximately 2 arcminutes of focus shift, while the other had a fraction-of-a-turn dead spot when the focus direction was reversed. This made precise focusing at high magnification more difficult than I would have liked.

The 125EC comes with an 8×25 right-angle finder with a focusing eyepiece — a vast improvement in usability over the ETX-90's straight-through finder. While stars at the center of the field were sharp, those slightly off-axis stretched out into astigmatic streaks.



S&T / GARY SERONIK

Although the ETX-125EC with Autostar can track the stars and planets, it is not an instrument suited to long-exposure astrophotography. The scope is, however, capable of producing satisfying snapshots of the Moon. The author obtained this view with a manual 35-mm camera equipped with a 2× teleconverter yielding an effective focal length of 3,800 mm.

Telescopes are compromises we look through — no one instrument can satisfy the interests of all observers. The ETX-125EC is not a specialist's scope — it is a general-purpose instrument with twice the light grasp of the 90-mm version. If what you're after is 5 inches of portable aperture with Go To capability and good optics, and you're willing to overlook the telescope's shortcomings, this just might be the compromise for you.

Go To: Celestron Style

In late July Celestron announced its entry into the budget–Go To sweepstakes when it unveiled the NexStar 5 — a 5-inch f/10 Schmidt-Cassegrain telescope. Naturally, amateurs interested in a computerized telescope in this size and price range will be closely comparing Celestron's offering with the ETX-125EC, and so will we. Readers can look forward to a future *S&T* Test Report in which we take a close-up look at both telescopes.

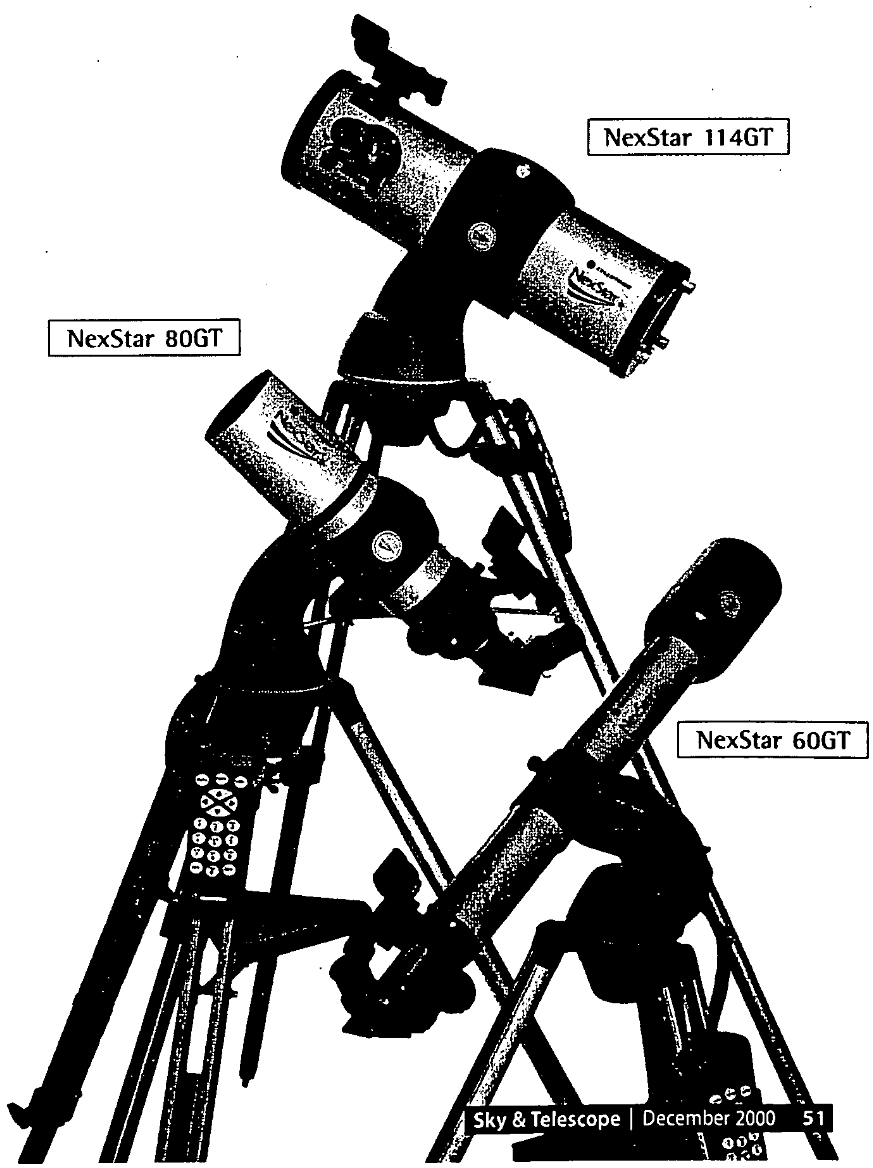
2000's Dueling Telescopes, Part II

THERE ARE MANY WAYS TO DEFINE A "BEGINNER'S" telescope, but if you accept that the first telescope that many people turn skyward is a low-cost refractor (the so-called department-store telescope), then the world became a lot more interesting for beginners this year. Celestron and Meade both launched lines of low-cost telescopes that redefine the concept of a first telescope.

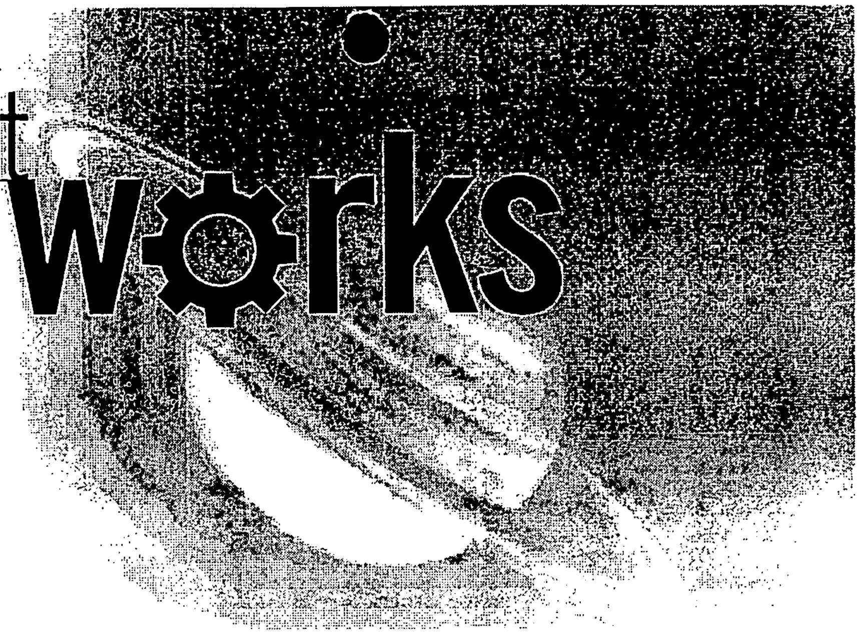
First to appear on the market were Meade's **ETX-60AT** and **ETX-70AT** ($299 and $349, respectively) that feature 60- and 70-mm achromatic objectives of 350-millimeters focal length. Both scopes come with quality eyepieces yielding 14× and 39× and the wide-field views that veteran observers recommend for beginners. Just as important, however, is the Autostar controller that comes standard with both scopes. With the push of a few buttons, the battery-powered Autostar will aim the telescope at any of nearly 1,500 celestial objects stored in its internal database, from the Moon and planets to star clusters and galaxies. And it all comes in a compact package that looks good enough to leave sitting on a living-room table when it's cloudy outside. The ETX-60AT and ETX-70AT are available from most stores and mail-order companies that carry Meade products. Contact www.meade.com for details.

As our Hot Products deadline approached, Celestron introduced three scopes to its attractive NexStar line that are all based on the same mount. The **NexStar 60GT** is a traditional 60-mm f/11.7 refractor (about $349) with 35×, 70×, and 175× eyepieces. The **NexStar 80GT** is a "short tube" 80-mm f/5 refractor (about $449) with 16× and 40× eyepieces. The **NexStar 114GT** is a 114-mm (4½-inch) "short-tube" reflector (about $549) with a built-in amplifying lens that yields an effective focal length of 1,000 millimeters at f/8.8. It comes with 40× and 100× eyepieces. All three scopes are supplied with a no-magnification Star Pointer finder, 1¼-inch eyepieces, and the battery-powered NexStar Go To computerized hand control. A worldwide dealer listing is available at www.celestron.com.

We are impressed with the potential of these low-cost telescopes. The "glamour" of computer-controlled pointing may be enough to distract retailers and first-time buyers from the long-held but misguided belief that high magnification is the sole selling point of a telescope. Each of these new offerings from Celestron and Meade is outfitted with realistic magnifications. The computer pointing eliminates the difficulty of finding objects, which most beginners discover only *after* they've purchased a telescope.



how it works



ADDING PRECISION CONTROL TO AN AMATEUR TELESCOPE SHOWS HOW SMART ELECTRONICS CAN ACCOMMODATE SYSTEM TRADE-OFFS AND CIRCUMVENT USER FRUSTRATION.

Telescope design integrates computer control with new approach to old problems

Bill Schweber, Executive Editor

COMPUTERIZED CONTROLS for amateur telescopes have been available for about a decade and can greatly enhance your sky-viewing experience. If you have ever used even a high-quality telescope to look at objects in the sky, you probably have hunted for and looked at a few objects and then felt exhausted from the difficulties of finding and identifying celestial bodies. Any serious viewing involves carefully setting up the scope; aligning it with known coordinates; using setting circles; establishing the right ascension, declinations, and azimuths; and tracking with a motor drive.

Meade Instruments Corp (www.meade.com), a leading vendor of telescopes and related optical systems, decided to use the latest advances in technology, along with algorithms developed for similar projects, to develop a computerized telescope and controller that would appeal to the serious amateur. This result means a unit that is optically far better than the $50 department-store telescopes that usually end up in the closet after a few uses. (You can recognize these cheapies because they usually boast high magnification, which is much less important in astronomy than aperture and light-gathering ability.)

The company's goal was to develop a unit that

Figure 1

The basic Meade ETC-90X/EC consists of a sophisticated telescope and a pushbutton handheld controller without intelligence.

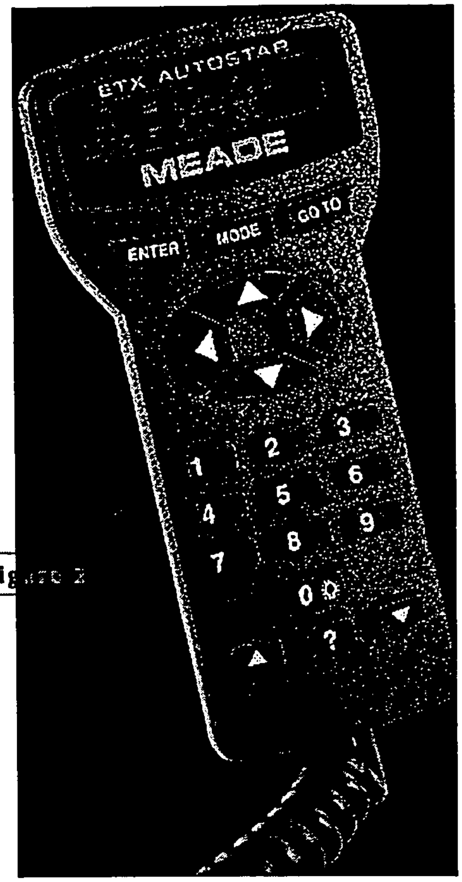
would provide excellent optical performance plus add a smart controller that would minimize the user frustration to get more amateurs interested in astronomy. In 1999, the company introduced the 90-mm aperture ETX-90/EC ($595) and associated Autostar controller ($149); since then, it has introduced similar but smaller apertures and thus much less costly telescopes that use the same controller and drive, as well as more expensive units with large apertures.

The design's engineering balances functionality, ease of setup and use, and low power consumption with some difficult cost limits. What's especially interesting is that the design doesn't just add a smart control unit to the motion of the telescope axes; it tries to redo the way that the user works with a telescope while also using the available processing power to overcome inevitable mechanical deficiencies and calibration issues.

The basic telescope comes with a two-axis motor drive and pushbutton handheld controller (**Figure 1**). This controller is a simple "up/down/left/right" unit that sends control signals to the motors but has no smart features. Within the telescope base are the motor, gear train, and just a few components (see **sidebar** "Driving that train"); the control intelligence resides in the handheld controllers.

The Autostar handheld controller is designed for small size, low power, and low cost, yet it must provide real-time control, positional calculations, a user interface, and an extensive database. Because the controller is designed for use in circumstances that are often awkward, it is limited to a two-line LCD and a relatively simple keypad (**Figure 2**). One of the main factors that made the unit practical is the reduction in prices of flash memory in the past few years by a factor of about 10. The internal database contains general information plus coordinates and motion data on 14,366 celestial objects categorized by groups such as galaxies and nebula plus about 50,000 words of text to describe the objects to the user.

One of the major goals of this project was to make it easy for any user to find, view them, and continue to view objects as the earth turns with respect to the stars or as the object moves with respect to the earth.



The real power of computer control occurs when the telescope's operation is connected to the handheld Autostar controller, which includes calibration, alignment, and motion-control algorithms; an extensive database; and real-time operating control.

DRIVING THAT TRAIN

The motors, gear trains, and associated electronics are critical to positioning and motion success of the telescope. Each of the two dc-servomotors is driven by a basic FET-based PWM (pulse-width modulation) controller, with the motors running at a maximum of 10,000 rpm. Each motor shaft drives the telescope through a 12,320:1 worm-gear drive which slows the motor, increases torque, and yields the right speed and accuracy combination.

The control is a closed-loop PID (proportional-integral-derivative) system based on a low-cost feedback encoder with just 36 vanes at the motor shaft. Although this encoder resolution is far too low for the positional resolution the telescope needs, the low resolution is multiplied by the gear ratio, thus yielding sub-arcsecond resolution of about 4928 encoder pulses per degree. The drive is a relatively low-powered unit. It operates from eight AA batteries or an external 12V source and can run with supplies that are as low as 6V; a fresh set of AA batteries yields between 20 and 40 hours of operation, even with regular motion and slewing. The system can direct the telescope at eight speeds ranging from a fast 5 degrees/sec to as low as 30 arcseconds/sec for image centering.

Every gear train has imperfections, backlash, and slack, which affect your actual achieved position compared to where the encoder indicates you are. One way to overcome this problem is to mount a high-accuracy, high-resolution encoder on the telescope-tube bearing rather than at the motor, but such an encoder and mounting are very costly and bring other mechanical and mounting problems. Instead, the Meade unit compensates by learning its imperfections.

The gear train is calibrated at the factory, and its unique compensation coefficients are stored with the controller. You can also recalibrate the system at any time by following simple instructions: Center the crosshairs of the telescope's spotting scope on any clearly visible landmark, then direct the telescope to slew to the left and back to nominal center, recenter it on the landmark, and repeat the process moving to the right side. This process also trains the system to learn any temperature sensitivities and performance variations.

The controller includes about 1 Mbyte of flash memory, and 60% of that memory is for the database. The remaining 40% is used for the program storage. Meade also developed a real-time operating system that includes 32 kbytes of RAM for the program

Users can, if needed, upload new programs or versions, sky tours, and object files into the flash memory as features are added, which is another benefit of flash memory. The database memory in the final design is twice as large as Meade originally intended because the company decided to enhance the user experience as much as possible by adding more objects and descriptions than originally planned; the drop-in flash prices made this possible. The large amount of memory dwarfs the relatively small 8-bit processor of the Autostar controller.

Your first step in setup is to indicate your positioning along with the current time. If you don't know your latitude and longitude, you can use the city you are near because the database has coordinates for 1300 cities. Next comes alignment, in which the synergy you can achieve between a smart controller and a precision-positioning system yields a new way of solving a long-standing setup problem. With the Meade unit, you simply level the telescope toward the horizon and point it roughly north. The controller then decides what stars are in your area, slews to get close to one of them, and has you check whether that star is in the view of the small, low-power spotting scope that is attached to the main barrel. If necessary, you use the controller to nudge the spotting-scope cross hairs over the designated star and into the center of the main scope's eyepiece, hit the enter button, and repeat the process with a second star.

At this point, the telescope has all of the information it needs, including the time, the scope's location, and its alignment. Punch the name or catalog number of a celestial object into the controller, and the unit slews at a high rate to that object and slows as it approaches and locks onto coordinates.

One factor that frustrates potential astronomers is that the objects in the sky are moving with respect to the telescope. The Autostar controller uses standard celestial-mechanics algorithms supplemented by Meade's proprietary variations and techniques to precalculate the motion of the target object and then move the scope so it follows that path. Most of the calculations are done in advance rather than in real time while the telescope is slewing and tracking, so the system's processor can handle the complex calculations.

This calculation and tracking is not limited to stars. The system can calculate and track the faster motion of planets. Even more difficult is to track the complex and much faster, earth-circling manmade satellites and space stations, such as Mir or the International Space Station. These objects have no fixed-parameter orbits; instead, their orbits change due to decay, deliberate ground-controller-initiated action, and other factors.

To track these objects, you can download the latest orbital parameters from Meade or other astronomy Web sites, and the controller performs the requisite calculations and precalculates the path. The controller then tells you how long until the object appears, gets ready for it, alerts you to begin viewing when the object appears in the observable sky, and begins to track the motion. Ironically, the moon is one of the most difficult objects to track accurately because of viewing parallax error, atmospheric refraction, inherent wobbling, and proximity to the Earth.

THE MOON IS ONE OF THE MOST DIFFICULT OBJECTS TO TRACK ACCURATELY BECAUSE OF VIEWING PARALLAX ERROR, ATMOSPHERIC REFRACTION, INHERENT WOBBLING, AND PROXIMITY TO THE EARTH.

If your astronomical ambitions are even more advanced, you can supplement the handheld Autostar with a cable linking the telescope to a PC. The PC can provide updated or enhanced database information, log your tracking and viewing data, and provide additional control functions. However, using a PC does not mean you don't need the Autostar controller. Instead of letting the PC replace the Autostar, and possibly compromise system performance and control while complicating I/O to the PC, Meade's engineers decided to make the relatively low-cost, dedicated Autostar a prerequisite to a PC link. Consequently, it provides the basic computer-based operation for the telescope with closely integrated coupling among critical real-time functions, the database, and the operator interface.□

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ACKNOWLEDGMENT

Thanks to Kenneth W Baun, vice president of engineering at Meade Instruments Co, for his time and explanations.

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2. di Cicco, Dennis, "A 'hot' telescope gets hotter," *Sky & Telescope*, May 1999.

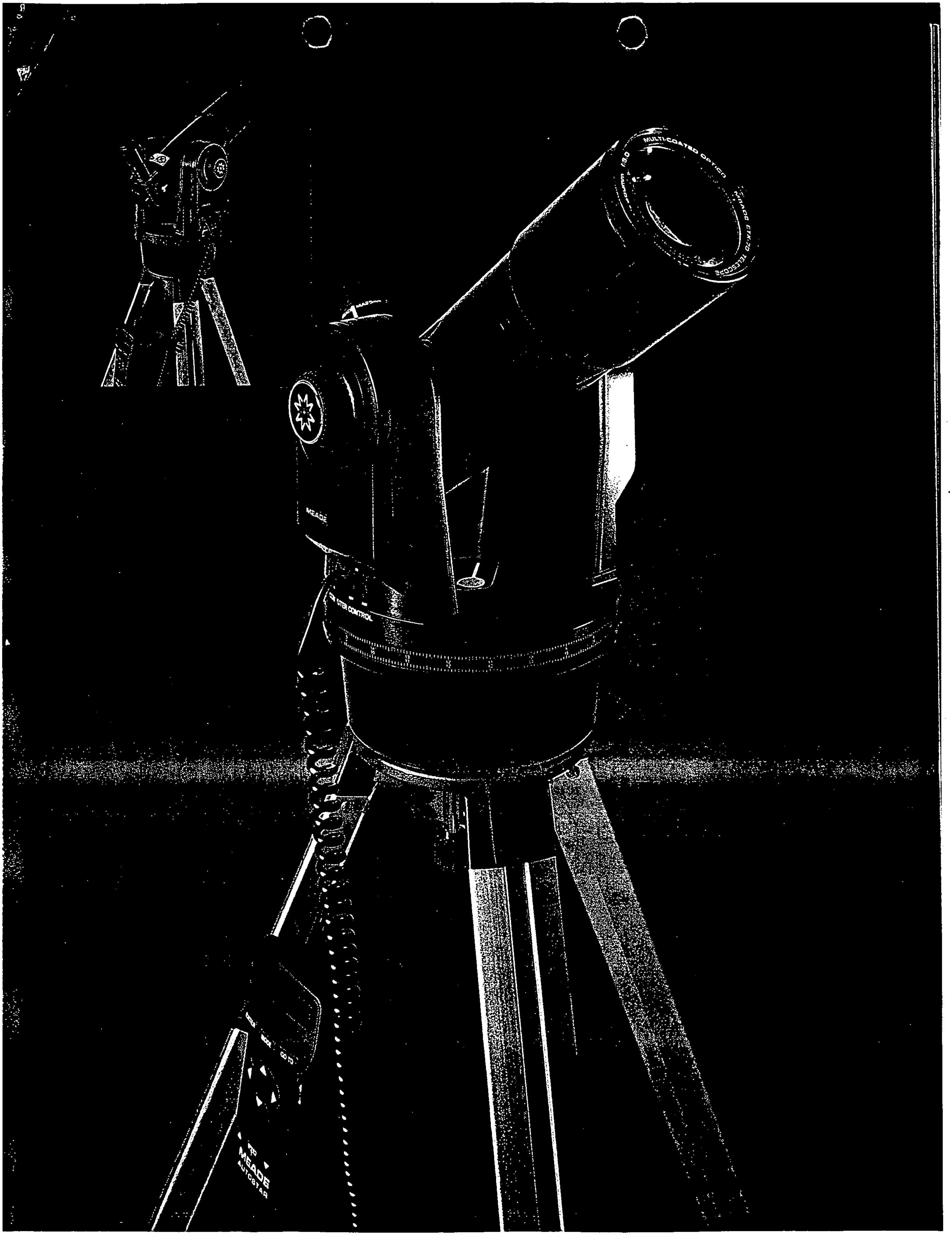
TELESCOPES FOR THE MASSES

Versatile and affordable, Meade's ETX-60AT and ETX-70AT refractors are automated guides to the night sky.

by David J. Eicher

DON'T DISMISS THE POWER OF MEADE'S NEW ETX REFRACTORS SIMPLY because they're small, short-focus instruments. The ETX-60AT and ETX-70AT scopes, introduced this summer by the California telescope manufacturer, are computerized observatories designed to bring astronomy to the masses. They are "plug-and-play" units that require only a few minutes to unbox, set up, and prepare for observing. The procedures involved in setup, alignment, and target acquisition are so thoroughly automated that a bright child could accomplish the whole task. And the telescopes are priced affordably enough (list prices of $299 and $349, respectively: "street prices" from dealers may be cheaper yet) that Meade hopes to broaden the hobby of astronomy in part through the popularity of these ETX models. Based on *Astronomy*'s testing, they should have every reason to succeed.

Meade's ETX-60AT (inset) and ETX-70AT refractors bring "go-to" technology to the beginner's telescope market. The computer-linked keypad and database of more than 1,400 objects allow users to dial-in objects and command the scope to find them.


MULTI-COATED OPTICS
MEADE
GO TO
MEADE
AUTOSTAR

The core of the ETX refractor idea is a computerized database that requires simple inputs from a keypad to recall its location, date, and time before it offers up a wealth of data including the locations of 1,471 objects including planets, asteroids, comets, stars, galaxies, clusters, and nebulae. This digital brainpower allows the telescopes to function as alt-azimuth units that can locate objects at the touch of a button and then track them effectively — after orientation with several defining stars — without an equatorial mount or polar alignment. The whole point of the telescopes is to deliver a simple design that works straight from the box and offers many targets to look at with minimal effort. To keep the cost low, complexity is limited to the computer system; the lenses are simple achromats (2.4 and 2.8 inches in aperture, respectively), and plain, effective 25mm and 9mm modified achromatic eyepieces are supplied. Other than the difference in aperture, the elements of the ETX-60AT and ETX-70AT are identical.

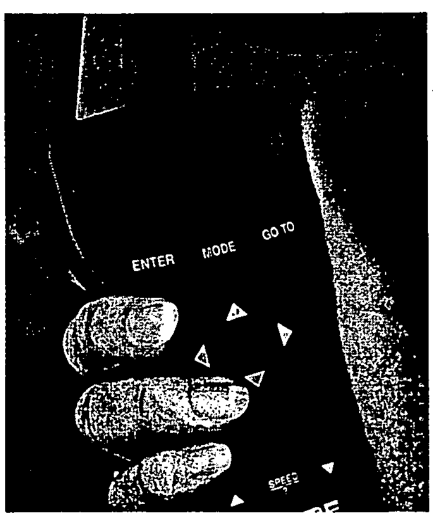
In decades past, the astronomy world has bemoaned the lack of an effective, affordable beginner's telescope. Something such as a 4-inch short-focus reflector might have sufficed in the past; the Meade ETX refractors are perhaps the first innovative beginner's telescopes for the present generation. And Meade surmounted significant challenges to produce them: Rather than churning out merely a good set of optics, they provide a user-friendly mini-observatory for the computer age.

Complexity on the engineering side translates into pure simplicity when the telescopes are unboxed. I tested the ETX units with the aid of an optional accessory, Meade's #882 Standard Field Tripod (list: $99). The tripod sets up like a heavy camera tripod, with lightweight aluminum legs and snap-locks to adjust height. A plastic accessory tray holds up to eight eyepieces and features a clip for the keypad. While one might initially hesitate at the lightweight design of the tripod, the system held up quite well during a moderate wind. Setting up the telescope is as simple as unfolding the tripod, attaching the base of the scope with two long thumbscrews that are supplied with the tripod, inserting six AA batteries into a compartment in the scope's drive base, and attaching the hand paddle. After these few steps, and after reading the introductory material in the owner's manual, prospective users of the ETXs are ready to step outside and initialize their scopes for observing.

A word about the manual: in a world made murky by poorly written, ambiguous owner's manuals, Meade's ETX effort stands out for its clarity, helpful and well-labeled pictures, and hints for beginners contained in boxes scattered throughout. A single addendum sheet listing two corrections was supplied as an insert. The manual presents a "quick-start guide" for those who wish to lunge into action, a well-labeled diagram of the telescope defining its components and features, and sections on the different ways the scope can be used. The telescopes are operational in a variety of ways: manually with or without "Autostar" (the name given the computer system, database, and hand paddle), in numerous Autostar modes that include guided tours of objects or the ability to slew to any of the 1,471 objects in the menus, or in advanced ways that include terrestrial viewing. For this last option, a clever flip-mirror is included so that users can turn a knob enabling upright viewing of scenery, birds, or other targets without contorting their necks.

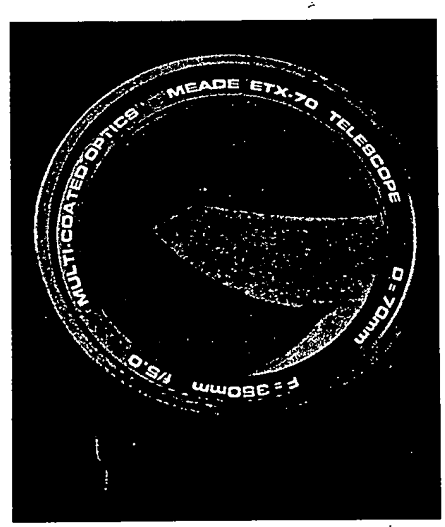
I spent about 15 minutes reading through the basics of the "getting started" section of the manual, attached the ETX-70AT to the tripod, loaded the scope with batteries, and took it outside for a test run. I considered this first encounter a rigorous test because I read only the basics, as I assumed many might do, before getting started. I also set up the tripod on my asphalt driveway, which is not precisely level, and followed the instructions for initializing the Autostar. I placed the telescope in its "Alt/Az Alignment Home Position," with the tube horizontal, declination at 0°, and aimed it, as instructed, roughly northward toward Polaris. The whole key to the telescope, the interface by which one controls it, is the paddle. It consists of an LED screen at top and 10 keys arranged in a trio below the screen ("Enter," "Mode," and "Go To" keys), four cursor keys in a circular pattern that allow moving the telescope, and three keys at the bottom, up, and down arrows that allow choosing options and a "speed" key that allows changing the rate of the tele-

The "Autostar" hand paddle allows ETX users to control modes of the telescope and to use the scope manually as well as automatically.

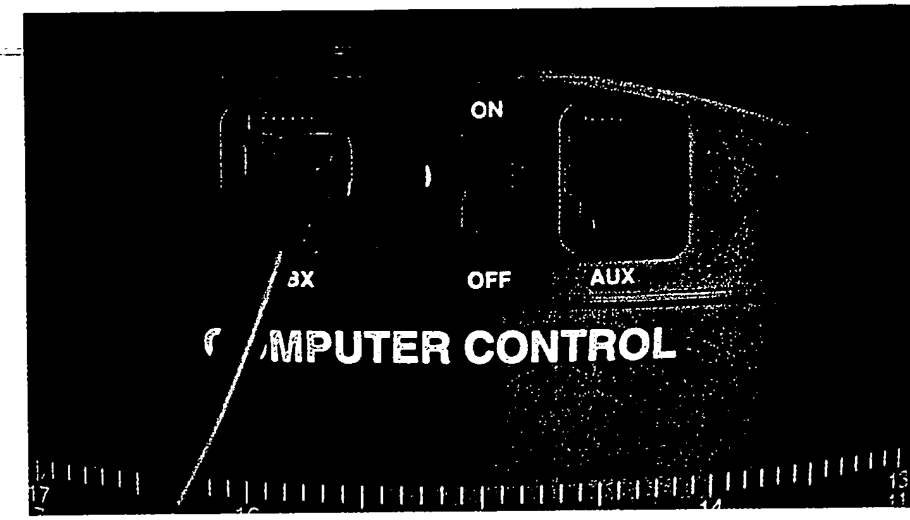


The ETX focusing knob is tucked inside the right edge of the eyepiece holder. The knurled screw is small; grasping it can be difficult.

The efficiency of the ETX refractor design comes from using the same parts for both models; only different lenses are employed.



A cleverly designed "flip mirror" knob on the left side of the eyepiece tube allows a quick conversion to viewing terrestrial sights.



The business end of the base contains the power switch and connections; amazingly, the whole thing runs on six AA batteries.

scope's slewing. The keys have multiple functions that are well explained in the manual and in automated instructions that scroll across the LED screen.

To initialize the scope, enter the date, time, whether or not daylight savings time is in effect, and observing location, and then proceed to alignment. In the simplest setup method, the telescope initializes itself by aiming at two bright stars; it then knows where it's aiming and can find the other objects by simple offsetting. Obviously the scopes are low-power, wide-field systems, but I had some degree of skepticism that the ETX would arrive on target at these alignment stars because it was only roughly aimed north and set on a non-ideal surface. With the 25mm eyepiece in place, I continued the setup and requested Vega as a defining star; indeed, the telescope slewed over very close to Vega, within less than a field of view away. I manually slewed the scope to center the bright star and continued with another rough test: using Altair as the second alignment star. Ideally, one would choose two stars that are widely separated to increase the accuracy of alignment. But I wanted to see how the scope would do under trying circumstances. The scope found Altair, placing it just above center in the eyepiece. I slewed it down very slightly to the center of the field, completed the alignment procedure, and proceeded to put the scope through its paces.

Even with such a simple alignment procedure, the scope performed as advertised. I chose two dozen objects widely scattered across the early autumn sky. I commanded the scope to go to the Ring Nebula, the Andromeda Galaxy, the Double Cluster, NGC 457, the Dumbbell Nebula, the Veil Nebula, the moon, Neptune, Albireo, Polaris, and many more. With the low-power eyepiece, every object was either well centered or the object was in the field but slightly off center and required only a momentary tap of a slewing button to exactly center it. Pretty impressive performance for such rough alignment and initial stars that weren't ideal; repeating the procedure with a more level surface and widely separated stars — Vega and Capella — later in the evening produced results that were slightly better. The telescope had advertised that with easy alignment it could reliably find object after object with the

A SIDE-BY-SIDE COMPARISON

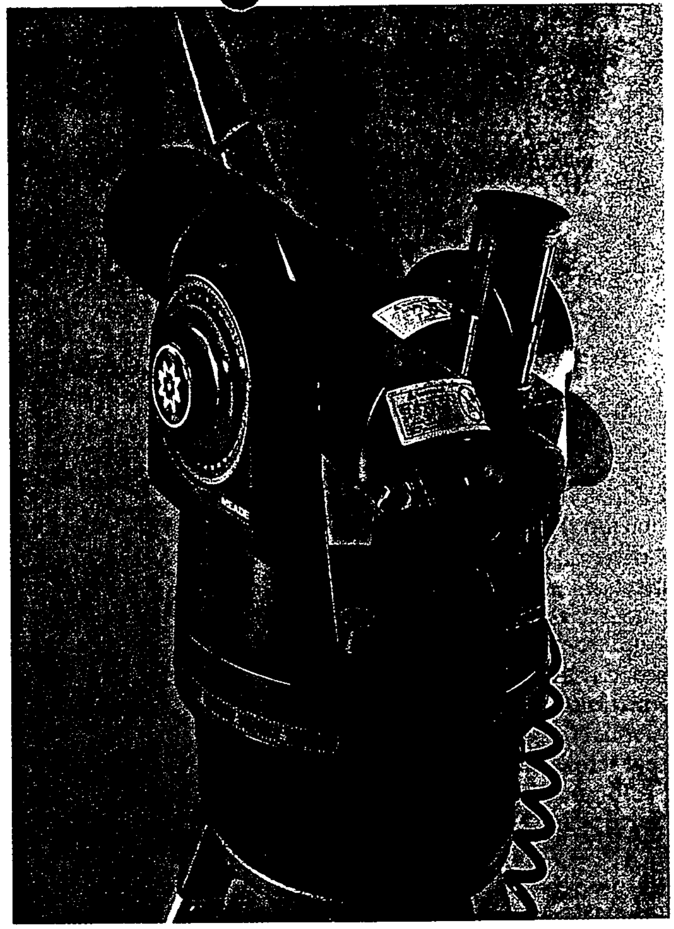
ETX-60AT Telescope with Autostar Hand Controller

Achromatic refractor, multicoated surfaces
Clear aperture: 60mm (2.36")
Focal length: 350mm (13.78")
F/ratio: 5.8
Near focus: 15'
Resolving power: 1.9"
Limiting magnitude: about 11.2
Eyepieces supplied: 25mm MA and 9mm MA, 1¼" barrels, yielding 14x and 39x
Dimensions: 15.9" by 7" by 9"
Weight: 5.8 lbs.
List price: $299 ("street price" may vary)

ETX-70AT Telescope with Autostar Hand Controller

Achromatic refractor, multicoated surfaces
Clear aperture: 70mm (2.76")
Focal length: 350mm (13.78")
F/ratio: 5
Near focus: 17'
Resolving power: 1.6"
Limiting magnitude: about 11.5
Eyepieces supplied: 25mm MA and 9mm MA, 1¼" barrels, yielding 14x and 39x
Dimensions: 15.9" by 7" by 9"
Weight: 5.9 lbs.
List price: $349 ("street price" may vary)

Meade Instruments Corp., 6001 Oak Canyon, Irvine, CA 92618 (949) 451-1450, www.meade.com.



press of a couple buttons, and its performance backed up these claims. It was impressive that you could go out and even after being relatively carefree about aligning the scope, it still worked. "Training the drive," a simple procedure described in the manual, should be done every three to six months to maintain a high level of pointing accuracy. The ETX-60AT functioned exactly the same way.

After using the telescope for a few hours, the sea-change in how technology will affect beginning observers struck me hard. When I started out as a teenager exploring deep-sky objects with a pair of 7x50 binoculars — comparable in light-gathering power to the ETXs — a laborious learning curve came attached to discovery. Sure, spreading maps everywhere and learning the sky in a detailed way impressed a good knowledge of the heavens into regular observers; by contrast, the potential of the computerized generation is startling. With the ETX, in a matter of minutes, I could see two or three dozen objects in rapid succession, finding them effortlessly and comparing their appearances much more effectively because they were so easy to locate. Who knows what intrepid deep-sky observers will emerge from this kind of technology when their thoughts can focus on the objects and what they look like more so than on the tricky star-hopping tests of simply finding them?

With the telescope up and running, users can explore a variety of objects: solar system, deep sky, constellations, or even satellites. After scrolling through a list displayed on the LED screen, you simply choose "enter" to highlight an object and then "go to"; the scope then slews with its relatively quiet whizzing and, when the object is centered, signals by issuing a little beep.

Both the 60mm and 70mm models performed well optically, particularly considering that they are low-priced achromats aimed at beginners. Images were sharp and detail good, but an achromatic lens is inherently imperfect; the very edges of the field were slightly blurry, not yielding an absolutely flat field like the one produced by a much more expensive apochromatic lens. The two-element lens also showed some color fringing on very bright objects such as the lunar limb.

After simple alignment routines, the ETX refractors accept commands to slew toward objects first in R.A. and then declination.

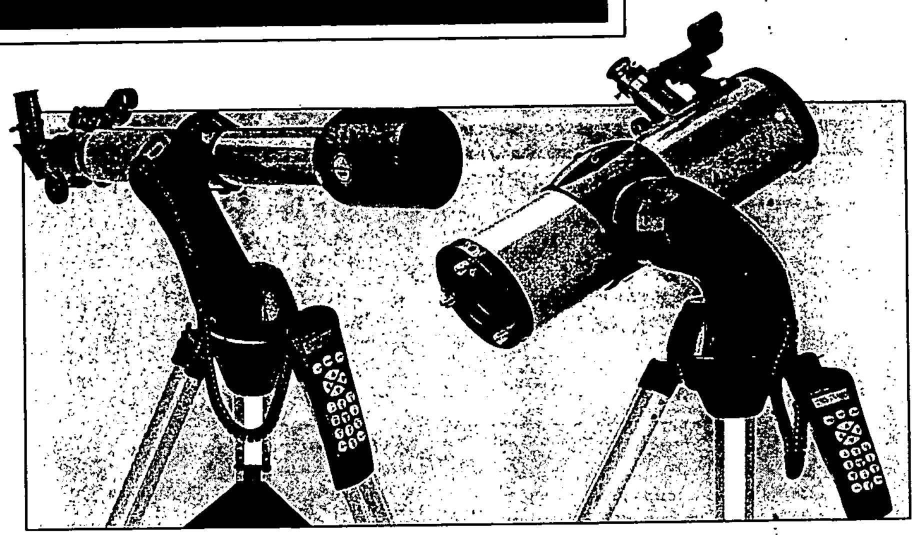
Meade offers a small array of accessories for the ETX refractors including eyepieces, filters, a carrying case, a finderscope, heavier tripods, and even software that allows attaching the scope to a PC and linking it to a database of more than 10,000 sky objects. Several paths of deeper involvement with the ETX line are available to beginners whether they enjoy deep-sky observing, lunar and planetary work, or photography.

After using the ETX refractors, it's clear that the telescopes work effectively and reach their goal of bringing introductory astronomy into a new phase. With their modest price tags, they are highly recommended for beginning observers, who will not only discover that they make finding and enjoying sky objects easy, but they bring a new kind of fun to spending nights under the stars. ▣

Dave Eicher is managing editor of Astronomy *and has been an avid observer for 24 years.*

STAR STUFF

PRODUCTS



Tasco StarGuide

Tasco has developed a telescope for children who are more adept at surfing the Internet than bagging Messier objects with a backyard telescope. The optics company has introduced a line of computer-guided telescopes that can automatically locate 1,800 or more celestial objects. The automatic feature, designed for beginners, eliminates the need for astronomical knowledge or mathematical calculations.

All but the most inexpensive StarGuide model offer a hand controller with scrolling text describing the object in view.

The scopes, which are available at Target stores in the United States, range in price from $149 (a basic model that does not include computerized go-to technology) to $629.

"Telescopes with computers create more hands-on learning," says Aaron Martin, an astronomy professor at Guilford Technical Community College in Jamestown, North Carolina. "It makes it simpler to locate objects in the sky. Even I had a hard time learning to navigate the sky."

The StarGuide telescopes are easy to assemble and set up. Each one comes with a Star Pointer finderscope that uses a red light-emitting diode (LED) display. The telescope computer has an "AutoAlign" function that makes calibration simple — even for first-time sky surfers. The computer enables the telescopes to find and track astronomical objects, avoiding the frustration of losing such objects as Earth rotates.

StarGuide 60

▶ This one is a 60mm f/12 refractor telescope. It is 28 inches long and comes with two eyepieces. An electric motor powered by eight AA alkaline batteries or a 12-volt AC adapter moves the telescope and runs its hand-held computer, which has red backlit buttons and a dual-line, 16-character liquid-crystal display screen with scrolling text. The computer also has a 1,800-celestial-object database and can automatically target and track those appearing in the night sky. The computerized "AutoAlign" function asks the operator to enter the date, time, and closest city, and the telescope automatically orients itself. Pressing the "Tour" key instructs the computer to find the best objects to observe that month and takes the user on a tour that comes with text readouts. The StarGuide also includes an RS-232 connector port that allows the user to control the telescope with a PC that has been loaded with software that comes with the telescope.

StarGuide 114

▶ This 114mm f/9 reflector telescope has a mirror instead of a lens, but it otherwise includes the same accessories as the StarGuide 60. However, for the $150 additional cost, the 114 provides much brighter views than the 60.

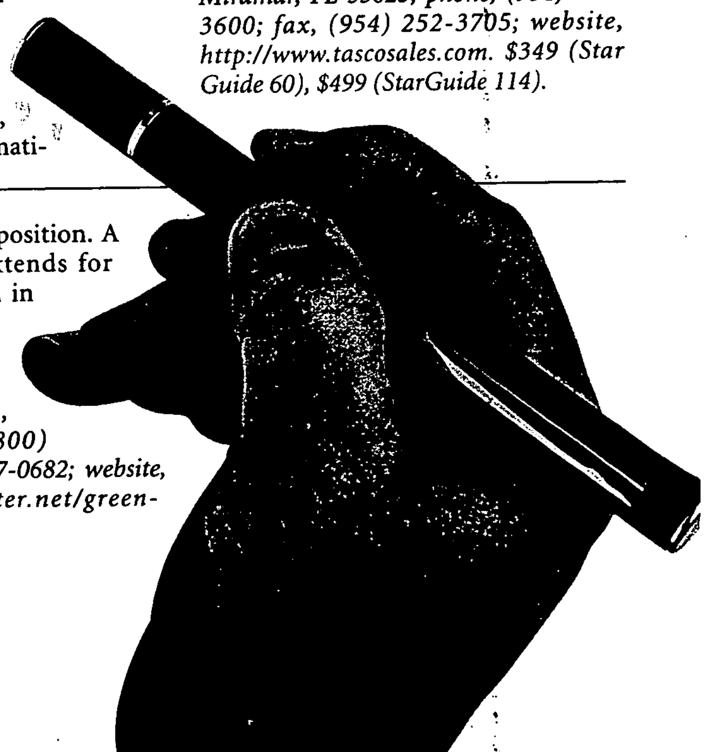
Tasco, 2889 Commerce Parkway, Miramar, FL 33025; phone, (954) 252-3600; fax, (954) 252-3705; website, http://www.tascosales.com. $349 (StarGuide 60), $499 (StarGuide 114).

Green Laser Pointer

▶ Laser pointers designed to help speakers making slide presentations at business meetings and lecture halls have become hits with astronomers. Laser pointers emitting light at 532 nanometers are popular because the human eye is more sensitive to this green light than red laser pointers operating at equivalent powers.

The Slimline GP5 is one such laser that astronomy instructors are using to point out stars. In the field, the laser saves time by allowing the user to simply point out an astronomical object he or she is talking about rather than pointing a finger and verbally describing the object's position. A shaft of green light extends for more than a mile, even in dim daylight.

DeHarpporte Trading Co., 6780 Vermar Terrace, Eden Prairie, MN 55346; phone, (800) 840-7829; fax, (621) 937-0682; website, http://www.laserpointer.net/greenlaspoin.html. $275.



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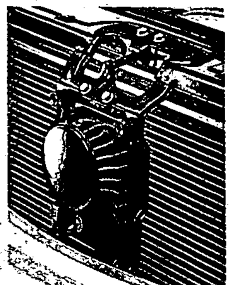
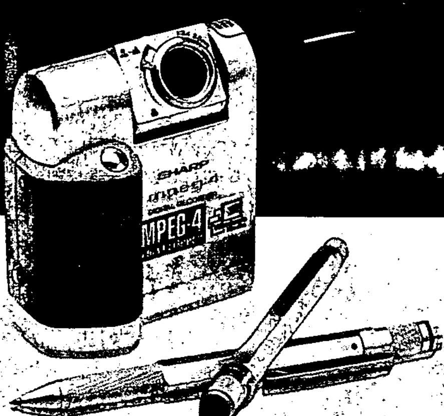
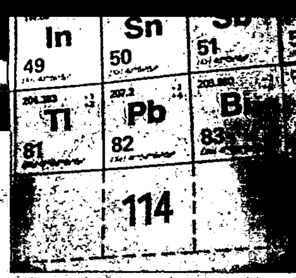
TECH TOUR DE FORCE The new Mercedes S-Class features unparalleled luxury and technology. The suspension system, for example, dispenses with springs and uses compressed air to adjust stability. At high speed, the chassis lowers automatically to reduce drag. A grill-mounted radar (left) sounds an alarm and automatically brakes the vehicle if it detects another car or an obstacle ahead. During a collision, airbags deploy according to the severity of the impact. And a voice-activated GPS navigation system makes sure you get to your destination. Price: around $70,000. ***www.usa.mercedes-benz.com***



TICKET TO THE STARS

Backyard astronomy has never been easier or more appealing than with Meade's Autostar controller. Plug the remote-control-size device into the base of the ETX-90-EC Astro Telescope, and you've got a tour guide to the stars. Without any prior knowledge of astronomy, you can find more than 14,000 objects. The controller calculates the position of heavenly bodies based on time, date, and location, and the telescope swivels to lock on for you. To get started, you point the telescope north and fine-tune the location of the two brightest stars in the sky. The controller does the rest—and, like a good tour guide, it even provides interesting facts on the LED readout screen. Prices: $149 (controller), $595 (telescope). ***www.meade.com***





INTERNET CAMERA Putting graphics on the Web became easier this year with the introduction of Sharp's wallet-size Internet View-Cam—the first camera designed specifically for the Internet. The camera takes still shots and video, which can be reviewed on a built-in LCD. It uses state-of-the-art MPEG-4 compression technology to keep files small so downloads are fast. Images are stored on removable SmartMedia cards for transfer to a computer. Price: $700. ***www.sharp-usa.com***

HEAVYWEIGHT DISCOVERY A team of scientists from Russia's Joint Institute for Nuclear Research and California's Lawrence Livermore National Laboratory reported in January that they had created an entirely new element, at that time the heaviest ever made, by bombarding plutonium with calcium atoms. Superheavy elements usually break down instantaneously, but the team kept their new element, 114, alive for a full 30 seconds. It not only filled in a blank on the periodic table but may suggest ways to create other long-lived heavy elements. ***www.jinr.dubna.su*** and ***www.llnl.gov***

Five "Go To" Telescopes for Beginners

There is a new breed of computerized Go To telescopes anyone can afford. Are they too good to be true? | **By Alan Dyer**

THERE'S NO POINT IN ARGUING whether computerized telescopes will revolutionize the marketplace. The facts are in — they are changing the concept of a beginner's telescope as no other product has done for at least two generations.

As evidence I point to a telescope-user's course I taught last January at the science center where I work. Of the 150 people in attendance, about one-third owned a computerized telescope (most being among the models reviewed here). A year earlier the same course had only one person with a Go To instrument. What a difference a year can make.

Until this past Christmas the entry-level market had been dominated for 30 years or more by virtually the same telescopes offered on the same mounts. Our hobby has enjoyed (or should I say endured?) a product stability (at least in the entry-level class) that would amaze any other industry. The same 4½-inch reflector I started with in the early 1970s is still available today on an identical mount and tripod, though thankfully it is now supplied with better eyepieces.

During those same 30 years experienced amateur astronomers have bemoaned many of the entry-level telescopes as being unsuitable. The images were fuzzy, the mounts shaky, and the fittings of poor quality. Using these "department-store" telescopes, as they came to be known, was usually a disappointment for first-time buyers, and many didn't survive the experience to stay in the hobby.

S&T TEST REPORT

Now, you can stroll into any big chain store and purchase a modestly priced telescope with capabilities once found on only top-of-the-line instruments. These mass-market products have redefined the department-store telescope. Gone are the claims of excessive magnification and hyped sales pitches such as "Professional 650× Model," which have lured unsuspecting buyers in the past. The new Celestron NexStar and Meade ETX instruments are genuine attempts to produce quality telescopes at prices beginners are willing to pay, and to

Entry-Level Computerized Scopes

Celestron NexStar series

Street Prices:

60GT 60-mm f/12 refractor $299

80GT 80-mm f/5 refractor $399

114GT 4.5-inch f/9 reflector $499

Celestron International

2835 Columbia Street

Torrance, CA 90503

Phone: 310-328-9560

www.celestron.com

Meade ETX-AT series

Street Prices:

ETX-60AT 60-mm f/5.8 refractor $299

ETX-70AT 70-mm f/5 refractor $349

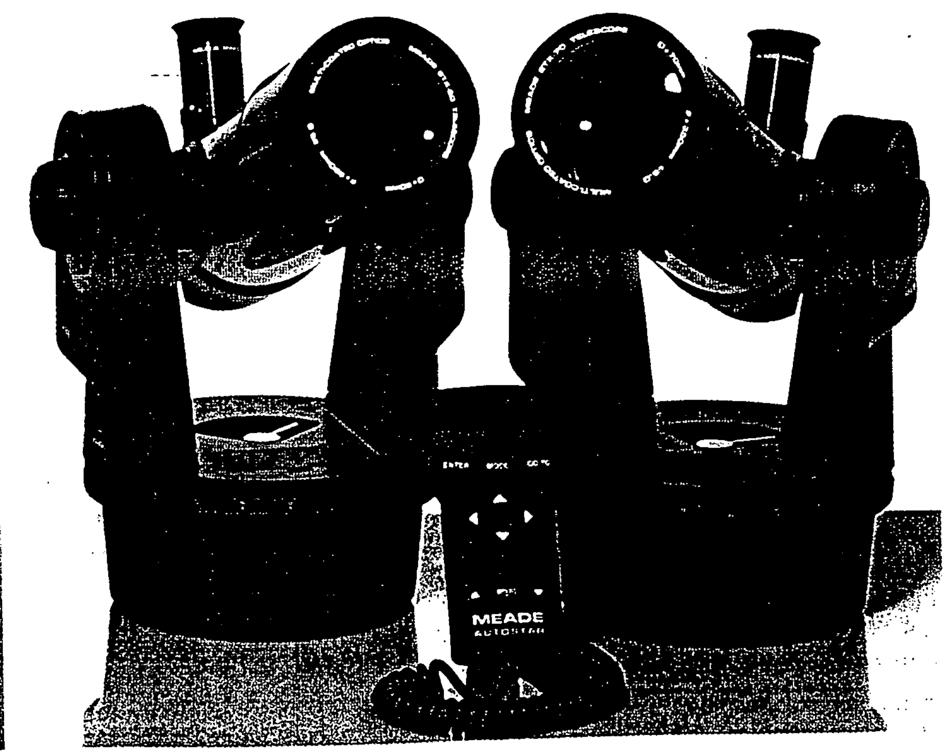
Meade Instruments Corp.

6001 Oak Canyon

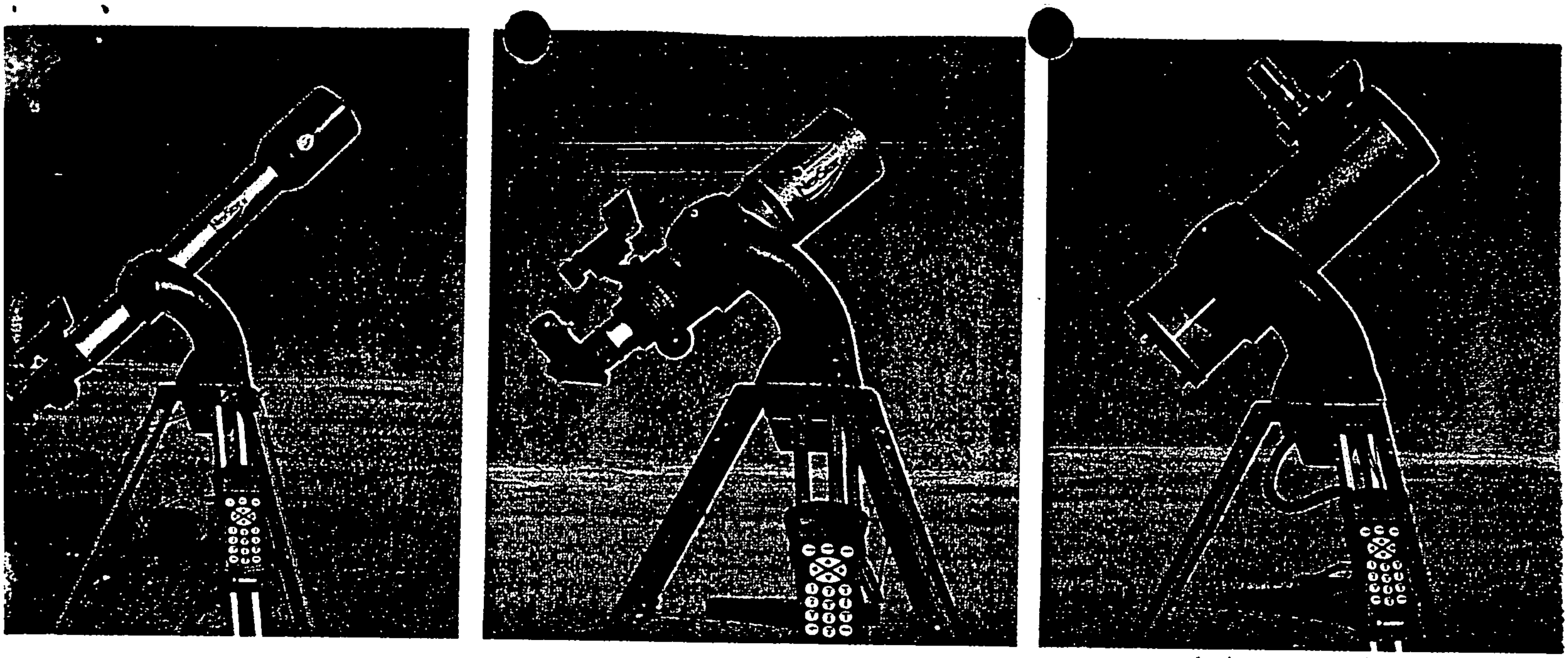
Irvine, CA 92618

Phone: 949-451-1450

www.meade.com



The Meade ETX-AT telescopes are refractors with two-element achromatic objectives of identical focal length, a very short 350 millimeters. This makes the 60-mm model an f/5.8 telescope, while the larger 70-mm model is an f/5 instrument. Other than the objective diameter, the two AT telescopes are identical in features and physical size. The only "penalty" in choosing the 70-mm AT *(right)* is the modest extra cost, but for 17 percent more money you get 17 percent better angular resolution and 36 percent more light-gathering power. *S&T* photograph by Craig Michael Utter.



The NexStar 60GT *(left)* is an f/12 refractor similar to Celestron's FirstScope 60 AZ model, while the 80GT *(center)* is a short-focus f/5 refractor similar to the now-discontinued FirstScope 80WA telescope. The optical-tube assemblies of all three NexStars (the 114GT is at right) are similar to other Chinese-made telescopes offered under a variety of brand names. These and all subsequent photographs are by the author.

package and market them as attractively, yet as honestly, as possible. That alone marks a revolution in the hobby.

The question is, do they work? If all we are doing is replacing one set of woes (poor optics, shaky mounts) with another (unreliable computer software and hardware), then the beginner may be no better served by the revolution. In two months of testing under trying winter conditions, I found that these low-cost Go To telescopes do indeed deliver. Even so, using one requires avoiding pitfalls that can trap new owners. And whether people are satisfied with the views will depend on the expectations they bring to the eyepiece.

One-Step Assembly

Meade's two ETX-AT models are entry-level versions of their popular ETX-90EC and ETX-125EC Maksutov-Cassegrain telescopes (reviewed in this magazine's May 1999 and February 2000 issues, respectively). The AT's Autostar controller is nearly identical to the version that powers the more expensive units, lacking only in the number of objects included in its internal database. The 60-millimeter AT tested was purchased at a Boston-area store. It was the last unit in stock and had clearly been opened and used. The 70-mm model was loaned by Meade.

The Celestron NexStar series, which started with the superb 5-inch and 8-inch models (reviewed in the February and November 2000 issues, respectively), now includes the Chinese-made instruments discussed here. The optics will be familiar to anyone recently in the market for a beginner's telescope. Our test units were loaned by Celestron.

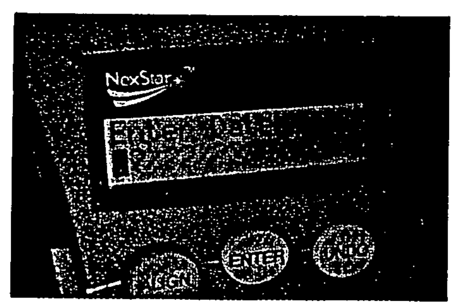
Assembling any of these five telescopes couldn't be simpler. All their Go To guts are integrated into the factory-assembled mounts. There is no need for users to attach motors or gears, which complicate the assembly of earlier models of budget Go To scopes. With these units, you bolt the telescope to the tripod and you're done.

The Celestron 114GT arrived from the factory with minor shipping damage — the tube had slipped in its cradle, causing one of its collimation bolts to chip the plastic cover on the mount. The 80GT reached me with a more serious problem — it refused to slew freely in azimuth, jamming on something inaccessible in the gear train. Since the scope had operated fine at the *Sky & Telescope* offices, the problem developed when the scope was in transit to me, perhaps because of rough handling. Celestron shipped a replacement directly to me.

All the telescopes come fairly complete. The principal accessory buyers might want to add to the short-focus refractors (the Celestron 80GT and both Meade models) is a good-quality Barlow lens (at least a 2×, if not a 3×, model) for high-power views of the planets. These telescopes have such short focal lengths that even their standard "high-power" 9- or 10-mm eyepieces provide only 40× magnification. While too much power is certainly a detriment, 100× to 120× is not unreasonable for telescopes of this aperture. With their exposed front lenses, a dewcap would be useful for the Meade scopes.

Setup and Alignment Ease

While these telescopes are smart, they still require an initial input of data and pointing at two known stars before they can automatically aim at astronomical targets. First, all the telescopes must be told the date, time, and the user's location on Earth. For the latter, each scope offers an extensive internal database of cities from which to choose. If your home is not near



The NexStar hand controller displays only "??/??/??" for the date, leaving users unclear what format it is asking for. The instruction manual does explain that it should be mm/dd/yy, but anyone outside the United States not used to this American format might enter "day/month/year" or "year/month/day" by mistake, then wonder why the telescope cannot find targets.

The NexStar 114GT is a 4.5-inch reflector with an effective focal length of 1,000 mm but with a tube only 18 inches (460 mm) long. The mirror is actually an f/4.5 primary augmented by a 2× Barlow lens built into the base of the focuser to double the effective focal length. Except for the finish, the tube assembly is identical to Celestron's FirstScope 114 Short reflector.

one of these cities, the Celestron scopes allow you to enter latitude and longitude coordinates directly. The Meades work differently. You pick a city from the list, then edit its coordinates to match yours, rename it as you wish, then store that new location. This worked well.

Both brands allow you to store cities or custom sites as your preferred locations so that you don't have to hunt through long lists to find them. Meade allows six locations, which you can name (a friendly touch), while Celestron allows nine locations identified only by numbers 1 through 9. At each startup the Meade software automatically defaults to the last location chosen, thus speeding up the initialization process. The Celestron software requires you to pick a location each time you use the telescope. Although simple enough, it entails a few extra keystrokes to page to your "user defined" sites and select the one you want.

In what I call "reviewer's luck," I quickly encountered a bug in the Celestron software. When you are selecting Canada as the country, Calgary comes up as the first city on the list — handy, as that's where I live. But as soon as this choice appeared, the telescope began an endless slew in azimuth. Hitting the Enter key stopped the slew but sent the telescope to Alpha Centauri or some other star invisible from Canadian latitudes, as if Calgary were in the Southern Hemisphere. All three NexStars exhibited this bug.

I managed a workaround by entering my latitude and longitude coordinates and storing them as my user-defined site number 1. From then on the NexStars were happy. Celestron is aware of the bug and is implementing a fix.

None of the five telescopes has an internal clock that keeps track of time when the telescopes are turned off. You must enter the correct date and time each night. The Meades remember the last date you used the scope, so you might have to key in only a new day and not the whole date. The Celestrons require you to enter the month, day, and year each time you power up.

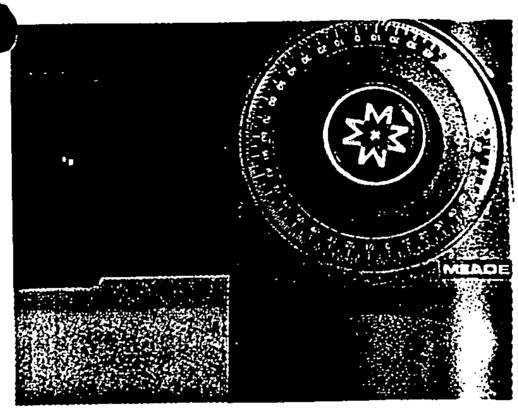
Once initialized with these data, all five telescopes need to be placed with their tubes level and aimed north. Hitting the Enter key starts an automatic alignment procedure. Each brand of telescope selects a bright star and slews to it — or to where it thinks the star should be relative to its starting position. You tweak the telescope's position with the electric motions to center that bright star in the eyepiece. That done, the telescope goes to a second star it picks for you to center. The telescope now signals that the alignment is successful and it is waiting for you to send it to the first target.

This procedure worked well with all telescopes. However, on rare occasions a NexStar would inexplicably select an appropriate star but point 180° away from where it really was in the sky. Switching off and trying the alignment again always smartened it up.

I found no bugs in the Meade Autostar alignment routine. All the Meade scopes worked fine out of the box with no need to train their drives, an improvement over the larger ETX scopes. Unlike those more costly models, the little ATs have no mechanical stops on the azimuth rotation, which also simplified setup.

Alignment Pitfalls

The alignment procedure is not without its potential for "pilot error." With all five telescopes it was easy to accidentally align on the wrong star. I did it myself one night, aligning on Castor when the scope was asking for nearby Pollux. If you have



Above: **The reviewer found that getting the telescope mount and tube level and aimed as close to true north as possible was important for finding and aligning on the right stars, and for accurately finding objects throughout the night. Here the mount and tube of a Meade AT are both level despite the declination circle being out of adjustment and reading –7° (it should read 0°).**

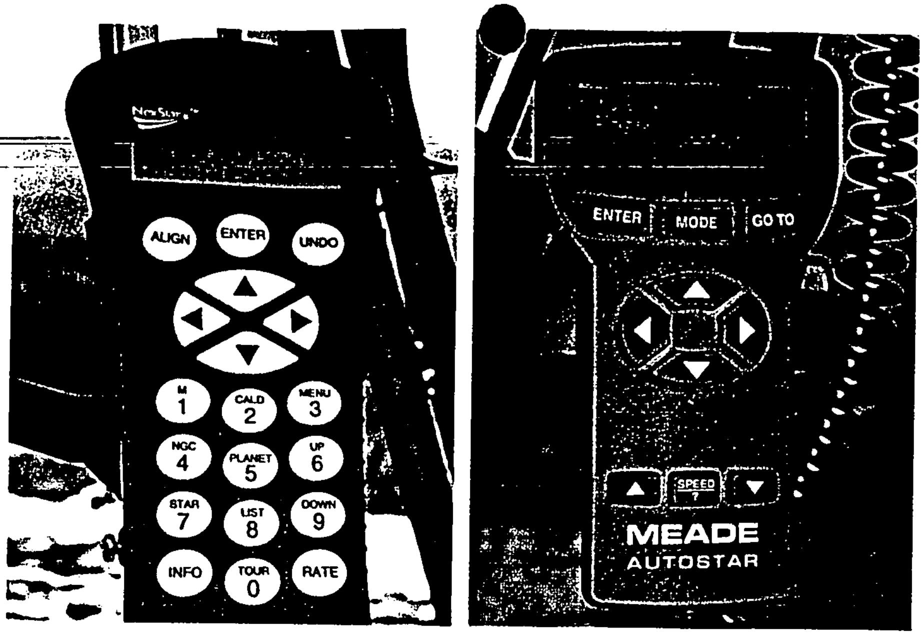
Below: **Each Celestron NexStar comes with a handy battery-powered "Starpointer" finder that needs to be attached and lined up, a simple process. When viewing through it *(top)* you see an illuminated red dot superimposed on the sky, a great aid to precise aiming. The Meades do not include a finderscope under the premise that the field of view of the telescope at low power is more than 3° and no finder is needed. But in practice, an add-on sighting aid would be a welcome accessory.**

not placed the telescope accurately (tripod and tube leveled and aimed north) it might end up pointing close to Sirius when the telescope really wants Rigel during the alignment procedure. If you center the wrong star, the telescope might accept the alignment but it won't find objects.

Also, all the telescopes will sometimes ask for stars that might not be obvious — do you know which Big Dipper star Alioth is? I can never remember. The Celestron manual thoughtfully includes a set of star charts with the alignment stars marked. The Meade manual contains only a crude chart of little help.

Celestron's Starpointer finder proved a useful aid for centering stars. Despite the 3° field of view with the Meade scopes, I found alignment stars often ended up outside the eyepiece field, requiring sighting along the tube to get close to a star. This crude method can lead to aiming at the wrong star.

In addition to their "Easy Align" mode, in which the scope automatically selects the alignment stars, the Meade ATs offer a manual "Two Star" method, in which you select from an internal list of 79 named stars. Celestron promises such a two-star mode in its instruction manual but the NexStar hand controller offers no such choice. The mode was deleted from the software after the manual was printed. The discrepancy is confusing but not serious since it is always possible to skip past an automatically selected alignment star (perhaps one that is hidden from view behind a tree) and choose the next one on the list. This is true for both the automatic Meade "Easy Align" and Celestron "Auto Align" modes.



The NexStar hand controller *(left)* uses a numeric keypad for easy entry of date, time, and object catalog numbers. The hand controller for the Meade ATs *(right)* uses simple direction buttons for scrolling a cursor across the screen, then incrementing up and down from 0 to 9. This takes more keystrokes to enter long numbers but works fine.

Aiming and Tracking Accuracy

I found that manually picking stars was often necessary to get an alignment good enough to find objects over a wide area of sky. Both brands of telescopes had a habit of picking alignment stars that were close together (Sirius and Rigel, for example). This worked well enough for finding objects in the south around Orion, but slew to the north and objects could easily fall at the edge of or outside the eyepiece field. Picking alignment stars widely separated in the sky improved pointing accuracy tremendously.

With good alignment, the pointing abilities of all the scopes were remarkably accurate. Objects routinely ended up not just in the field but close to the center of a low-power view. For much of the sky I logged pointing accuracies of ½° or better, including for the Moon and planets. However, objects far removed from alignment stars could be off by as much as 1° to 1½°. For the short-focus refractors this error might still place the object in the field of a low-power eyepiece, but the higher-power NexStar 60GT and 114GT are less forgiving. With these scopes, objects far from alignment stars will sometimes end up outside the field, possibly leaving new users lost in space.

Even so, with either brand when objects were out, they were usually out by a similar amount in the same direction. So the error was at least consistent. This suggests that most pointing problems are due more to errors in alignment rather than flaws in the motors, gears, or software calculations.

As a check, one night I purposely set up telescopes poorly, either far out of level or aimed 15° east of north, as if at magnetic rather than true north for my area. Under both conditions, the telescopes accepted their alignments (using widely separated stars in the south and overhead) but still had trouble pointing accurately to objects in the north, often missing targets by up to 2°. Starting over with the scopes initially level and aimed true north brought northern objects well into the field.

On rare occasions when slewing to a target, a NexStar would stop short of its destination by several degrees in azimuth yet provide no indication that anything was wrong. Going to another object and slewing back again to the missed target resulted in a correct pointing. This, too, is a known bug Celestron is fixing.

Once on target, all these telescopes track by pulsing the motor on each axis by the correct amount to keep the object in the field as the sky turns. The Meades tracked objects flawlessly. Even after three hours, Jupiter remained near the center of the field. The two Meades also tracked objects through the zenith without complaint, a tricky task that requires an alt-azimuth telescope to perform a quick about-face.

The Celestrons were less accurate in tracking. Even on AC power and with what seemed like good alignment, after an hour Jupiter would be about 3° out of the field. The NexStar telescopes consistently did not travel fast enough to keep up with the moving sky. However, for the casual visual observing for which all these telescopes are intended, the Celestrons were fine since they kept targets in the field for many minutes at a time.

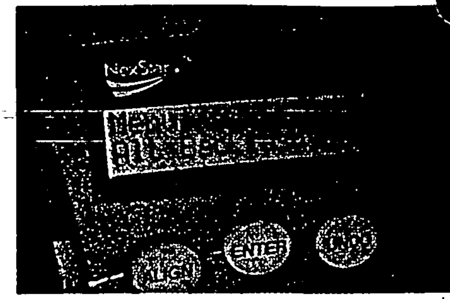
I could not perform a zenith-tracking test on any of the NexStars because none of the three telescopes can reach the zenith — their tubes all hit the base or tripod legs at some point. The software also allows a NexStar telescope to aim at objects below the horizon and in doing so can cause a collision between tube and mount. This doesn't damage anything, but it does ruin any alignment.

Slewing and Braking

The Celestrons slew slightly faster than the Meades, but in timed races both brands ran virtual dead heats, counting from when the Go To command is issued to when the telescope beeps or flashes that the slew has finished. While the Meades take ~~slightly longer to perform~~ their initial fast slew, they tend to get closer to the target (often placing it within the field right away). They then brake quickly and perform a fine motion to jog the object to its final position. This last movement typically took about 10 seconds. There was no overshoot and no protracted centering process.

The Celestrons follow a different philosophy. Their fast slew stops them well short of the target. They then perform a slow motion that gradually creeps the target into the field. This final "settling in" usually took about 15 to 20 seconds but unpredictably could take as long as 45 seconds to a minute.

To remove backlash in the gears, the Celestrons always approach an object from the south and east. So even a short jog from M42 to M43 in Orion, for example, would swing the telescope far off the object then slew it back again close to where it was originally pointed. In this situation the Meades would simply move the required few arcminutes.



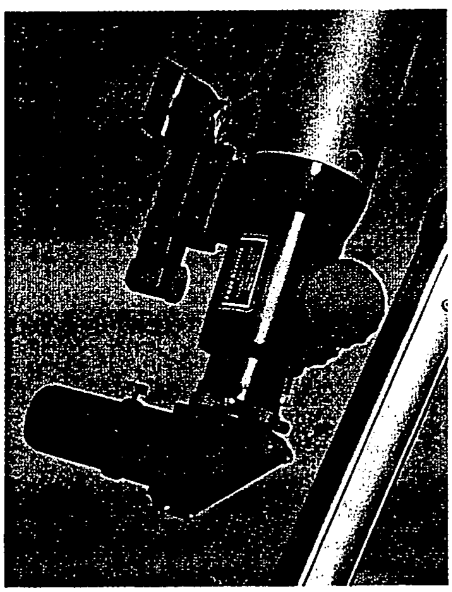
Hitting the Menu button and scrolling down brings you to the Alt Backlash and Az Backlash settings. Entering a value of 050 made the NexStars move smoothly when jogged with the direction buttons. Inconveniently, you have to enter these backlash numbers each night. Future versions of the NexStar software will remember a user's backlash settings.

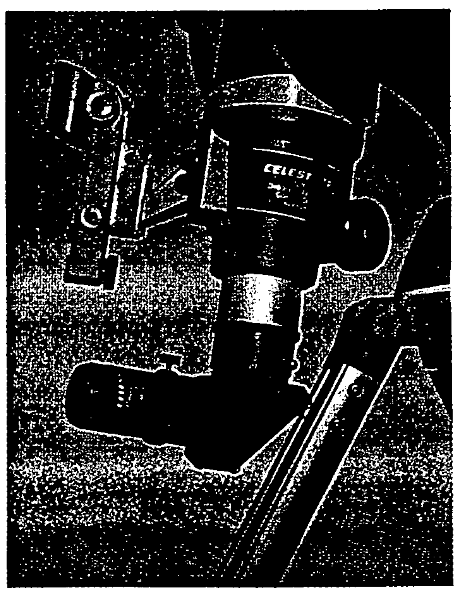
When performing fine movements with the hand controller, the Meades exhibited little backlash or slack in the gears, just a slight wobble in altitude when jogging in azimuth.

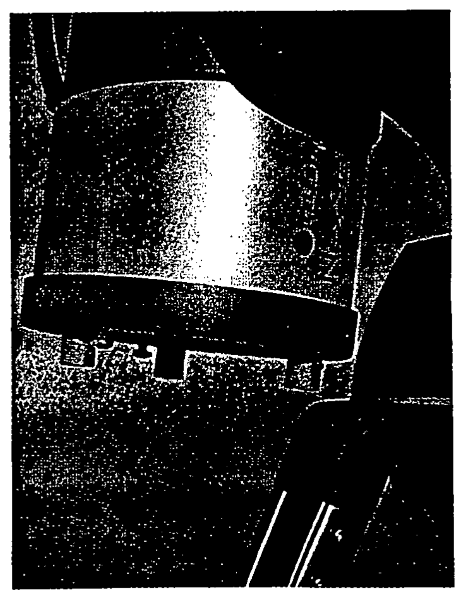
Here, too, the Celestrons performed differently. The software's default backlash compensation proved so excessive that attempting a fine movement in one direction would jolt the telescope far in the other direction. Centering objects required a constant fight with the telescope to move it where I wanted. The solution was to hit the Menu key, then scroll down to the Alt Backlash and Az Backlash settings and enter a value of 050 for each. The manual makes no mention of this critical adjustment.

Database Differences

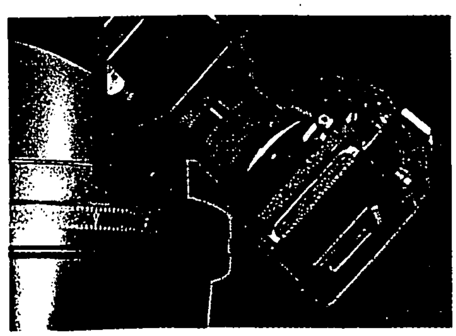
The Celestrons contain a larger database of objects (4,033 versus 1,471 objects in the Meade software). For most people this disparity isn't as great as it might seem at first, since the main difference is simply in the number of SAO stars included. Nevertheless, the Celestrons do have a larger number of deep-sky objects as well — 1,180 versus what I counted to be 274 unique objects in the Autostar lists. The 274 includes all Messier and Caldwell objects, as well as a handful of NGC and IC objects not contained in the Messier and Caldwell lists. The Meades include unusual targets such as 34 nearby stars, 11 stars with planets, 11 quasars, and 3 black holes, though objects in these last two categories are beyond the reach of these scopes.



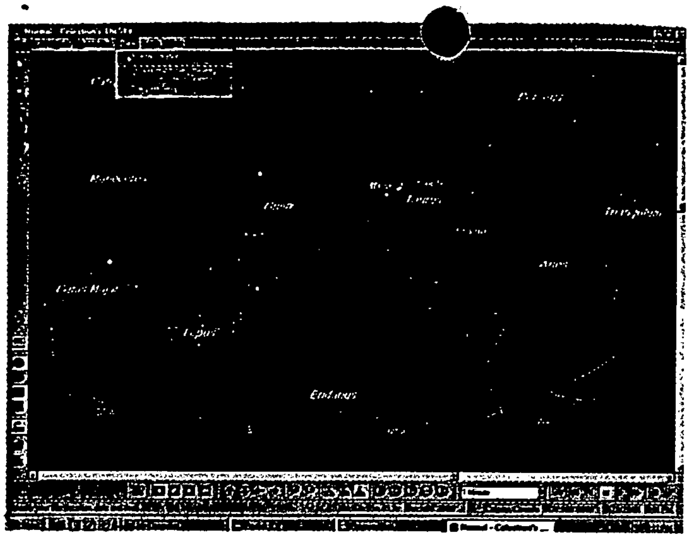


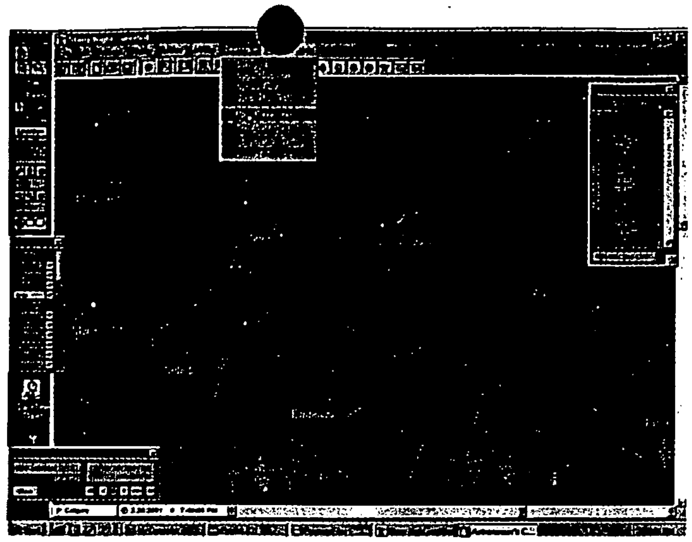


All three NexStars collide with their tripod legs when they approach the zenith. The 60-mm NexStar *(left)* aims to +70° altitude before hitting tripod legs; the 80-mm *(center)* reaches +80° altitude. The 114-mm NexStar can aim as high as +84° if you move the tube as far forward as possible in its cradle. Doing this upset the balance of the telescope, but it didn't seem to bother our test unit. Celestron explained that zenith avoidance and horizon limits will be added to future versions of their software.



Right: While a 35-mm SLR camera can be attached to the rear port of the Meade AT, the telescope cannot then aim higher than 45°. While the ETX-90 camera adapter shown here fits the smaller ATs, the camera will not reach focus. The thinner camera adapter (catalog number #64ST) made for the AT models is essential.





Both companies now bundle an excellent software package with each of their Go To telescopes. Celestron includes a Level I edition of the latest version of *TheSky (left),* a very capable and full-featured program. This bonus software does not, however, offer any telescope control function. Meade includes the "Bundle Edition" of *Starry Night (right),* a repackaging of the original *Starry Night Deluxe,* one of the author's favorite planetarium programs. Included is a third-party program called *Astronomer's Control Panel* that allows telescope control from a computer using an optional serial cable. All the programs are Windows only — Mac users are out of luck.

Although it contains a larger database, the NexStar software provides very little cross-referencing between deep-sky catalogs. You never learn that Caldwell 1 is really NGC 188. Call up NGC 188 and you are not told this is also object number 1 in the Caldwell list. Similarly, double stars with proper names, like Algieba, are not also given by their better-known Bayer designations, in this case Gamma Leonis. Other unnamed stars are listed only by Celestron's own catalog number, not by their SAO numbers.

The Meade software contains a far more extensive library of text information about many more objects than does the NexStar software. As such, these little scopes work well as "online" teachers, providing small paragraphs of astronomy information about hundreds of targets. You can even point to a constellation and learn its mythological story. Celestron plans to upgrade the extent of its scrolling text comments in the future.

Software Sophistication

From my testing, I give Meade the commanding lead in the sophistication of its superb Autostar software. A handy Identify function worked well — I manually slewed the telescope to several deep-sky objects, and the Autostar correctly identified their NGC numbers. The hand controller provides accurate calculations of sunrise, sunset, moonrise, moonset, and lunar phases, among other sky events. Users can adjust the display's brightness and contrast, and to save battery power the display goes to sleep after a few minutes of disuse.

The Meades include a useful Park function that sends the scope to its home position, where it can be shut off without losing its alignment. Provided you don't move the telescope, waking it up from Park allows you to find daytime targets such as Venus, or to continue another night's viewing without having to realign.

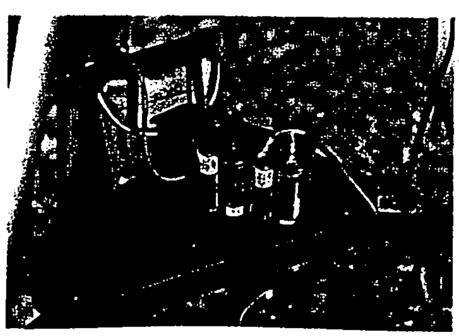
The latest update of Autostar software I tested, version 1.0E, adds a Cord Wrap function. However, even without it the hand controller cable didn't seem to tangle. The Celestrons, on the other hand, had a tendency to always turn in the same direction, wrapping the battery and hand controller cables around the mount. As with the other deficiencies I encountered, Celestron plans to correct this by adding a cord-wrap function to future versions of its software.

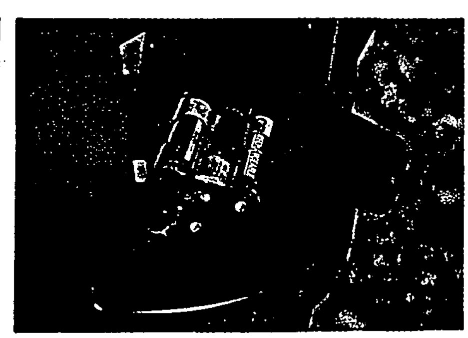
Both brands offer a Tour function. The Celestron tour contains 77 objects for the whole sky, starting with objects currently due south and working east as you scroll down the list, or west as you scroll up. The Meades I tested offered three tours: Tonight's Best (a good tour of bright objects of all types); How Far Is Far? (a tour of objects from near to far); and A Star's Life (a tour of objects representing stages in the life of a star). These are creative uses of the computerized Go To function. More tours will be added through software updates available via the Internet.

Battery Life and Cold-Weather Woes

All this sophistication is for naught if your batteries die. The disadvantage of these

The Celestrons *(left)* use an outboard pack of eight AA batteries or can be powered from an optional AC adapter. Either way a cord runs from the power source to the rotating telescope mount, causing occasional tangles. The cordless Meades *(right)* operate off an internal set of six AA batteries. Though not a factory option, the Meades can be operated off a larger external battery pack or an AC adapter rigged to clip onto their battery connector.





SKY & TELESCOPE

THE FIGHT OVER PLUTO

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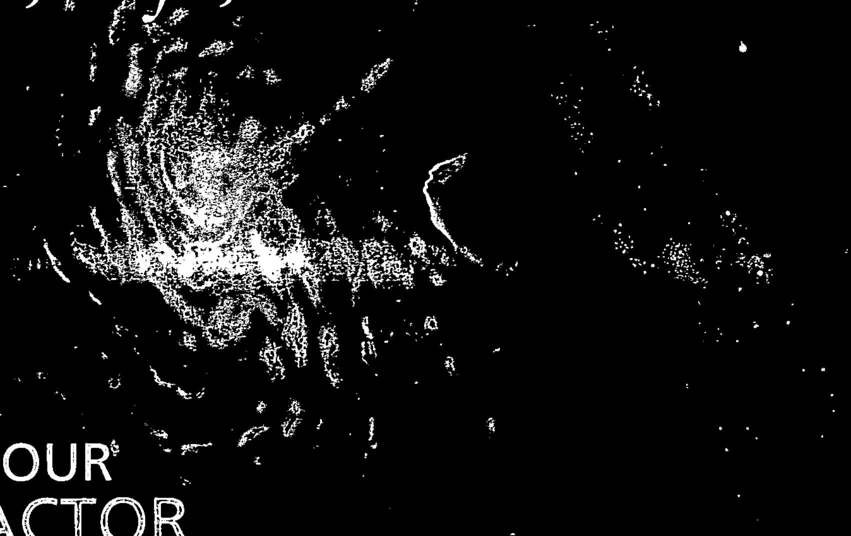
MAY 1999

Quasars

Their Birth, Life, and Death



GETTING THE MOST OUT OF YOUR SMALL REFRACTOR

THE FAINTEST OBJECTS EVER IMAGED BY AN AMATEUR ASTRONOMER

BLUE MOON BLOOPER

Everyone's Telescope

As you can read in this month's *S&T* Test Report (page 61), Dennis di Cicco loves Meade's new ETX-90/EC with Autostar control. I'll not soon forget how this grizzled veteran effervesced in my office as he described the system's abundant goodies. (To get details out of the way, you can buy this 3½-inch, state-of-the-art telescope — optically, mechanically, and cybernetically — for $750, the cost of a good TV set.)

A prediction: The ETX/Autostar concept will go down as the greatest happening in amateur astronomy yet. Indeed, I believe it will grow the hobby on a scale heretofore unimagined.

S&T / CHUCK BAKER

I've always had one answer to this perennial question: Why aren't there more amateur astronomers? My take is that it's simply too hard, too time-consuming for most people to learn how to find things in the sky, especially if their first telescope is a small, rickety, tiny-field, department-store deadbeat. And, beyond the equipment, they have to become familiar with polar alignment, right ascension, declination, setting circles, and all the other arcana that's needed to find celestial stuff the old-fashioned way. That was true 40 years ago when I entered the hobby. It's even more true today, because people have less free time. In one brilliant stroke Meade's brainy ETX system has erased the learning curve.

Purists will argue that the essence of the hobby will be lost to beginners because they won't have to "earn their stripes" to become "real" amateurs. The purists have a point; nothing is gained without a price. But to them I say: Please weigh the cost/benefit ratio and give time a chance. Let's hook people on astronomy and then give them the opportunity and support to learn about its intricate, intoxicating subtleties.

I see a huge societal impact by the ETX/Autostar. Suddenly there is no excuse for anyone with even the slightest interest in astronomy *not* to become a participant. The nighttime sky is now readily accessible to teachers, scout leaders, environmentalists — anyone whose gray cells don't quit at night. If you know where north is (even roughly) and can level the telescope's tube (even roughly), the sky's the limit!

The ETX is small, for sure. But so was David. Autostar is the brain that will defeat the Goliath of mysticism, academe, and technobabble that has made astronomy seem beyond the ken of most ordinary folk. Now anyone can play the backyard-astronomy game cheaply and without fear of frustration. I'll bet thousands of kids this year will see the Ring Nebula, NGC 188, or M78 with the ETX/Autostar. That wouldn't have been possible a year ago because few could have found them.

The ETX/Autostar is not just a new telescope system. It's a revolution! Its impact on amateur astronomy and science education will be unprecedented.

Leif J. Robinson

SKY & TELESCOPE®
The Essential Magazine of Astronomy

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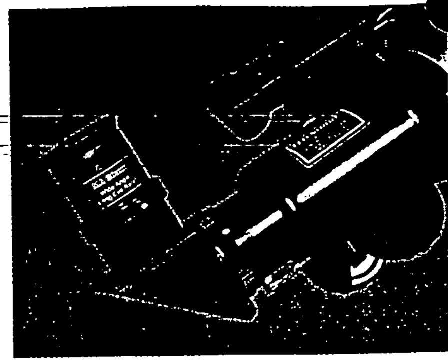
(Continued from page 58.)
judged them in need of replacement. The Celestron 80GT refractor showed triangular star images at moderate power, indicating pinched optics in its plastic lens cell. The Celestron 60GT refractor had spherical aberration and miscollimated optics bad enough to noticeably blur planets. The Meade 60AT showed strongly elliptical star images at moderate to high power, a case of astigmatism sufficient to make it impossible to achieve a sharp focus.

The replacement units supplied by the manufacturers were far better. The replacement Meade 60AT showed a fair degree of spherical aberration in a star test performed inside and outside of focus. The Meade 70AT fared much better, showing only a slight miscollimation and a little spherical aberration. At 116× the scope showed bright, in-focus stars as distinct and clean Airy disks with bright first diffraction rings and dimmer second rings, a sign of good optics. I judge our test unit 70AT to be a fine beginner's scope for general-purpose observing.

The replacement Celestron 60GT had more spherical aberration than the Meade 70AT, though not as much as the 60AT. Jupiter appeared pleasing enough for a casual view. The replacement Celestron 80GT's optics were out of collimation — stars in focus at high power had a flare on one side. The 114GT reflector also arrived with its optics slightly out of collimation. Unlike the refractors, the reflector's optics can be collimated by adjusting the primary mirror. Once tweaked, the 114GT showed only mild spherical aberration and provided good views of the planets. On deep-sky views with its low-power eyepiece (and with premium Tele Vue Panoptic and Orion Lanthanum Superwide eyepieces), stars in the outer third of the field appeared severely elongated due to coma, despite the f/9 focal ratio.



Following classic "department-store" tradition, the Celestron 60GT refractor comes with a focuser and a star diagonal that appear to be all plastic. The star diagonal is equipped with a prism so small it vignettes the field of 32-mm and 26-mm Plössl eyepieces. Owners of the Celestron 60GT would benefit from upgrading its star diagonal and poor eyepieces to ones of better quality.

Through the three short-focus refractors (Celestron's 80GT and the two Meades) Jupiter appeared as a yellow-green tinted disk surrounded by a blue-magenta glow, a level of chromatic aberration inevitable in low-cost refractors with f/5 focal ratios. As expected, the 60GT refractor showed minimal chromatic aberration due to its f/12 focal ratio.

At high power all the telescopes gave views of the planets that can best be described as soft. While Jupiter's two broad equatorial belts were visible, even the best instruments showed just a hint of other thinner belts. The Cassini Division in the rings of Saturn was there but not etched with high contrast.

Where these telescopes excelled was in low-power views of deep-sky objects. That is especially true of the short-focus refractors. Even the little Meade 60AT provided wonderful wide-field views of winter star clusters and nebulae made all the more enjoyable by the ease of finding them. Exploring a dark sky with the Meade ATs and their superb software was a lot of fun.

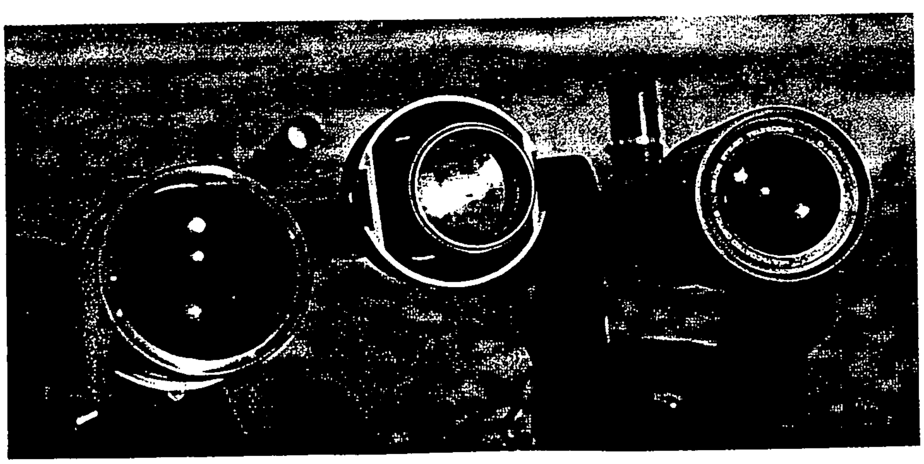
Conclusions and Recommendations

Both companies have honed their Go To hardware and software to perform far beyond what I might have expected from such low-cost telescopes. I was particularly impressed with the Meade ATs and their well-engineered Autostar controllers. They were a pleasure to use. The Celestron NexStar controllers will benefit from the promised revisions, though even now the essential functions work well.

At $300, and especially if the tripod is included, the Meade 60mm AT is an attractive choice for anyone looking for a low-cost telescope that is more than a plastic toy. Because of its better eyepieces and internal software, I'd recommend it over the Celestron 60GT. Or better yet, step up a notch to the Meade 70AT or Celestron 80GT. All three short-focus refractors are compact and appealing. But city-dwellers should keep in mind that from an urban backyard, these scopes' deep-sky views will be washed out by the sky background. And their planetary views may disappoint because of their low power and limited aperture. I feel these are telescopes best suited to a dark-sky observing site.

Because of its aperture and focal length, the best telescope of the five for planetary viewing was the Celestron 114GT. Once cooled down and collimated, its optics gave satisfying color-free views of the planets. This may be the best choice for urban observers.

I would rave with greater enthusiasm for these market-changing telescopes had I found consistently good optics. These are remarkable telescopes for the money, but there's still room in the marketplace for old-fashioned but well-made refractors and reflectors you push around the sky by hand and brain power.



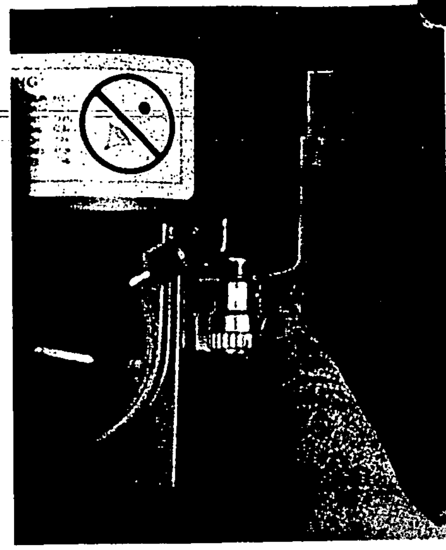
The Celestron 80GT at left and Meade AT telescopes (the 60AT is at right) had good multicoatings on all their objective-lens surfaces. The Celestron 60GT (center) had minimal single-layer coatings on its air-to-glass surfaces.

Alan Dyer *frequently reviews astronomy gear for* Sky & Telescope. *Last January he reviewed SBIG's STV integrating video camera.*

and all high-tech telescopes is the demand for power. Rather than simply stop working, both brands of telescopes often behaved erratically when battery power dropped, slewing uncontrolled or moving in fits and starts. In a pinch the Meades can be unlocked from the motor drives and the scopes aimed by hand, but the Celestrons must have working batteries.

At room temperature the Meades gave out after about 10 hours of continuous tracking and occasional slewing. The Celestrons lasted a similar length of time under similar usage. Outside at night with subfreezing temperatures (a typical winter night for much of North America), both brands of telescopes gave out after only 2 to 3 hours using conventional alkaline batteries. Switching to rechargeable nickel metal hydride (NiMH) batteries improved cold-weather endurance to 5 or 6 hours of continuous use.

Considering their demand for batteries, I suggest the most useful accessory for these telescopes would be a set of NiMH batteries and a charging unit. The Celestrons can be operated off AC power but with the hassle of tangled cords that might pull the plug on you by accident. On the other hand, in cold weather, running on AC allowed the Celestrons to keep functioning long after the battery-only Meades had faded away.



When the Meade AT refractors are aimed at elevations above 45° the focus knob becomes difficult to manipulate, especially with gloves on. One trick is to run your finger against the knob as if it were a thumbwheel.

The Celestron hand display remained readable on the coldest nights, while the Meades' scrolling text turned into a line of gibberish, despite my best attempts to adjust the brightness, contrast, and scroll speed. Static text, though sluggish to refresh on cold nights, was always readable.

Focusing

The two Meades are probably the first telescopes I've had trouble focusing. A small focus knob turns a threaded rod that slides the front lens up and down the tube with ultrafine movement. It takes a lot of turning to change the focus. Switching between the supplied 25- and 9-mm eyepieces, for example, requires 14 turns of the focus knob. Meade told me that the 9-mm eyepiece is being modified to have its focus point more closely match that of the 25-mm eyepiece, so this will be less of an issue in the future.

By contrast, all the Celestrons use conventional rack-and-pinion focusers that were smooth, quick, and easy to adjust with gloves on. Only the 114GT reflector proved tricky to use — its depth of field is so shallow that the slightest twist of the focuser would throw the image far out of focus.

Mount Stability

All the telescopes proved commendably stable on their respective tripods. Both Meades took between 1 and 1½ seconds to damp out vibrations after a mild rap to the tube. The rubber feet on the tripod are an essential item; without them the damping time was at least 3 seconds. Most of the wobble in the Meade ATs originates in a play between the top plate to which the fork arms attach and the cylindrical base of the telescope, and not in the connection to the tripod itself.

The single-arm forks and wide-stance aluminum tripods of the Celestrons proved solid. The 60GT had a damping time of 2 seconds, the 114GT about 1½ seconds, and the stubby-tubed 80GT less than a second.

Eyepieces and Manuals

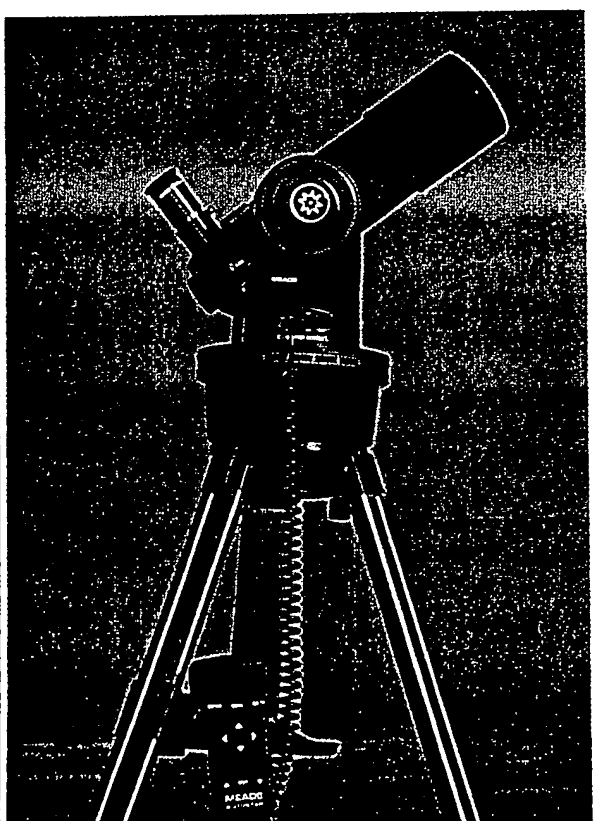
Most of the telescopes came with good-quality 1¼-inch Kellner-class eyepieces, called Modified Achromats (MA). The exception is the Celestron 60GT. Its 20-, 10-, and 4-mm MA eyepieces were a notch down in quality. The 20-mm eyepiece gave acceptable views, though its label of "wide-angle" is questionable. Its apparent field is not much better than any other budget MA or Plössl eyepiece, about 50°. The 10-mm MA has "tunnel vision" with its 35° apparent field. The 4-mm MA eyepiece has a more normal field but virtually no eye relief. This is the high-power eyepiece that gave department-store telescopes their bad reputation. In my opinion it should not be sold with any telescope.

The Meade instruction manual was thorough, albeit brief, in its descriptions of the Autostar's many functions. The Celestron manual needs amending to bring it in line with the actual software installed and to provide more details on the NexStar's full suite of functions.

The Optics

These are budget-priced telescopes intended for general-purpose observing with low to moderate magnifications. Nevertheless, of the five telescopes originally acquired for this review, three had optical problems severe enough that I

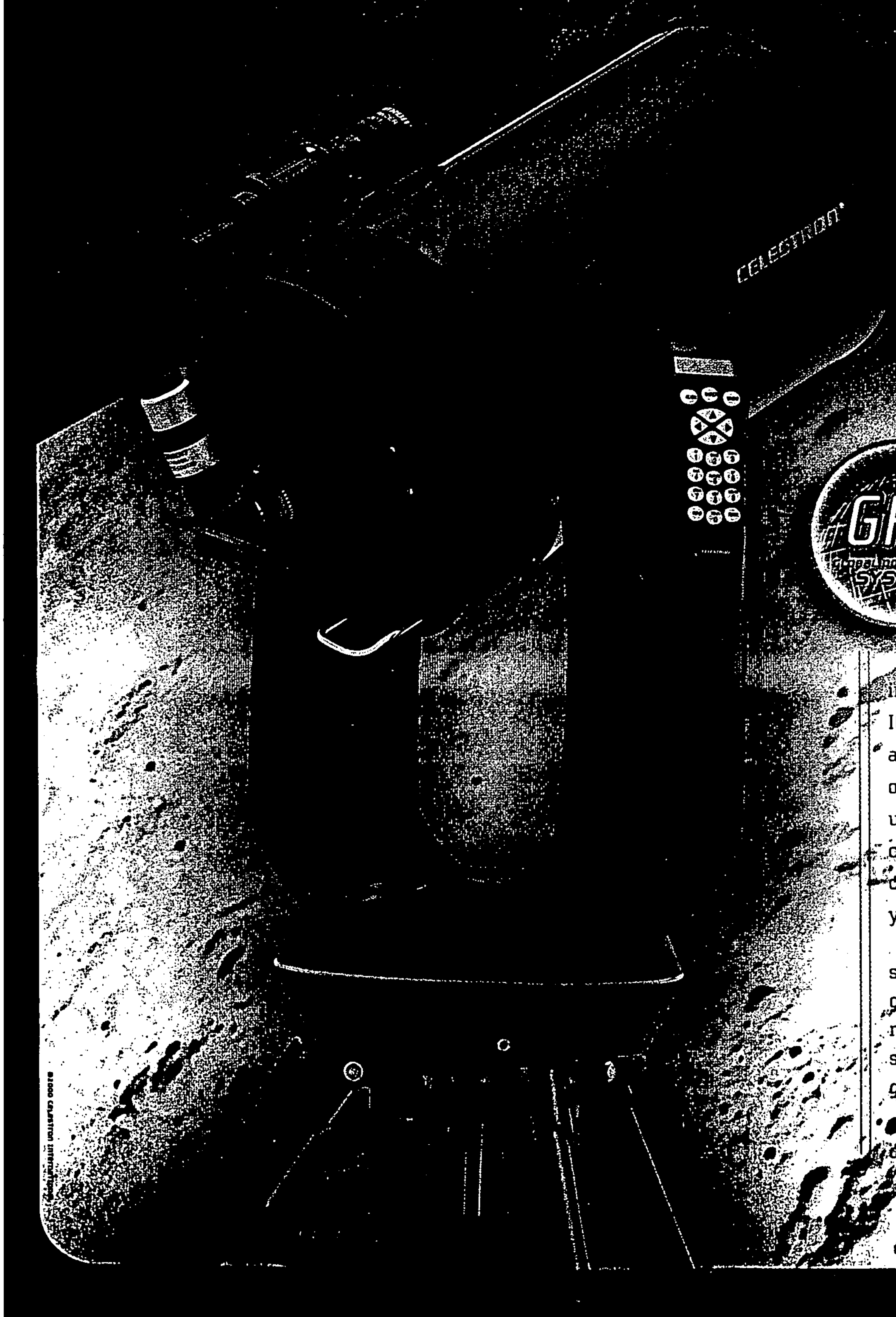
(Please turn to page 60.)



The Meade ATs can be used without a tripod by being placed on a sturdy table. But the AT's lightweight #882 Field Tripod (shown here) does make viewing in all directions much easier. The tripod legs don't open very far, making for a slightly tipsy telescope. The NexStars attach to their tripods with one large knurled knob, while the Meades attach with two large bolts, easy to manipulate with a gloved hand. The bolt pattern on the base of the AT models is the same as on all of Meade's ETX scopes. Originally optional, the Meade tripod is now standard equipment.

THIS IS WHAT HAPPENS WHEN YOU TELL YOUR ENGINEERS THE SKY'S THE LIMIT.

2001 - MAR, APR



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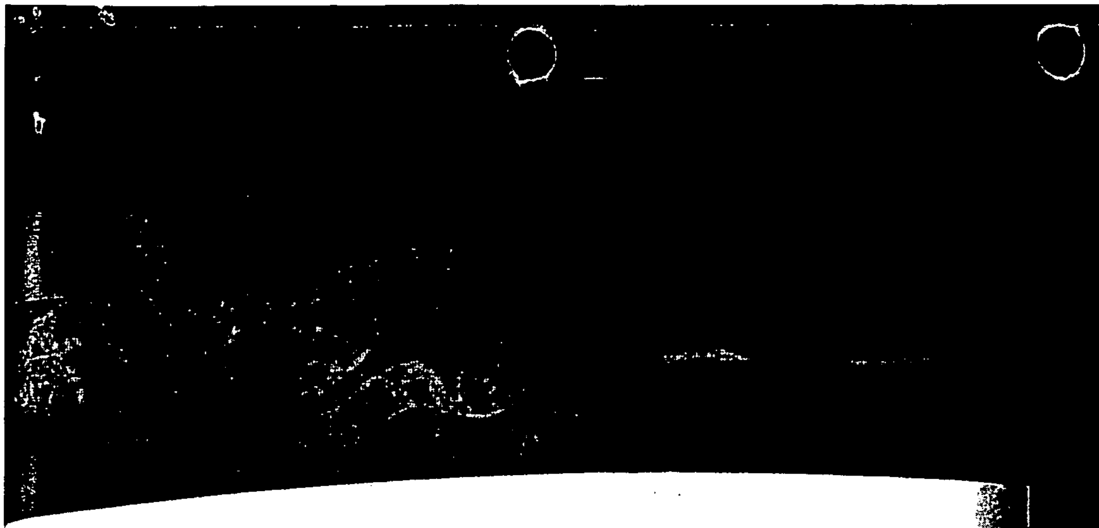

How about that NexStar® 11 GPS has **21% more light gathering power** than competitive 10" models. Or that the NexStar® 11 GPS is the first commercial telescope to incorporate a feature to prevent cord wrap, possible because all power comes through a non-moving drive base.

The NexStar® 11 GPS is also the only commercial telescope that has a **carbon fiber optical tube.** This aptly dubbed space-age material is lightweight, incredibly durable and has lower thermal expansion than aluminum and other metals. Making it perfect for the job at hand.

Each optical element in the NexStar® 11 GPS is individually hand figured and guaranteed to be diffraction-limited. Incredibly, Celestron is the only large commercial telescope builder to employ hand figuring – a complex optical procedure where ultra smooth corrections are made to the secondary mirror to ensure consistently high quality. Additionally, the primary and secondary mirrors have Starbright™ coatings applied for maximum reflectivity, with anti-reflection coatings on both sides of the corrector lens to provide maximum light transmission.

Combined, this long list of features makes the NexStar® 11 GPS the ultimate portable, large aperture telescope. Ideal not only for lunar, planetary and deep sky observing, but also for astrophotography and CCD imaging.

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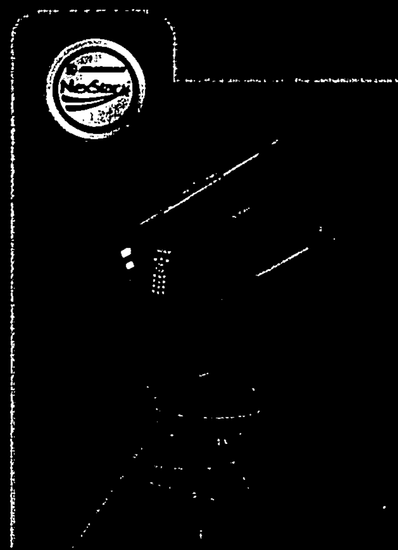

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- Upgradeable via the Internet

ELECTRONICS:
- Computerized hand control with easy-to-read backlit liquid crystal display (LCD) unit
- Permanent Periodic Error Correction (PPEC) – once periodic errors are recorded for elimination, the telescope maintains the recording even when turned off and on
- Built-in, adjustable backlash compensation
- Dual ports for RS-232 communication with a PC to operate and use with the telescope (one on hand control and one on base drive)
- Dual ports for serial communication with future smart accessories
- Solo port for AutoGuider
- Solo 12V DC power output for accessories

MECHANICAL
- Dual die-cast aluminum fork tines
- Large 9.5" roller bearing track for an ultra-stable polar axis
- 5.625", 180-tooth gears in both axes with precision worms (for accurate tracking)
- Hand control rests in its built-in home within the fork tine for easy usage

DAMPING TIME
- Less than one second

OPTICS
- 11" (279mm) large aperture Schmidt-Cassegrain optical system
- Focal length of 2800mm at f/10

WEIGHT
- Telescope weighs only 65 pounds
- Tripod weighs only 26 pounds

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standard:	optional:
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• carbon fiber tube	• car battery adapter
• 1¼" star diagonal	• eyepiece filters
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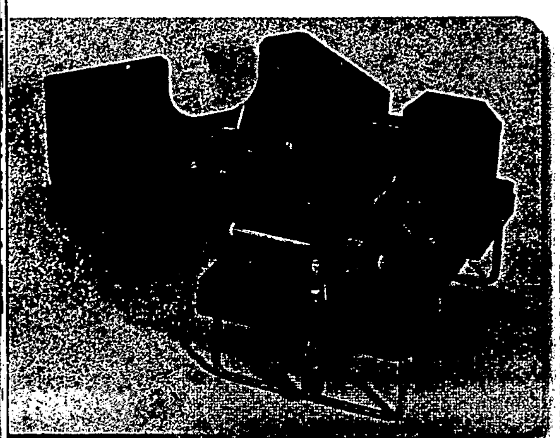
Pointing the Way

S&T / CHUCK BAKER / CRAIG MICHAEL UTTER

COMPUTER-POINTED TELESCOPES WERE A SHOW-STOPPING NOVELTY at the beginning of the 1990s, but the decade drew to a close with them relatively commonplace. Nevertheless, priced upward from roughly $3,000, these instruments attracted mostly serious amateurs. That changed in 1999 when Meade, the world leader in computer-controlled telescopes, introduced **Autostar,** which was reviewed in last May's issue, page 61. By itself, this ergonomically friendly, hand-held device stands as a tribute to the miniaturization of computer electronics. But when connected to some of Meade's newest telescopes, it is nothing short of revolutionary. In the extreme, it cut the cost of a computer-pointed telescope by almost an order of magnitude while offering features unavailable on even the company's previous top-of-the-line computerized scopes. Autostar is the future and it's available today. It is currently an option (priced between $99 and $149, depending on the size of its internal database) for the revamped ETX-90EC Maksutov telescope and its bigger brother, the 5-inch ETX-125EC. Autostar also works with Meade's Digital Series telescopes, which include 60-, 70-, 80-, and 90-mm refractors, as well as 4½- and 5-inch reflectors. Check out www.meade.com for a listing of dealers worldwide.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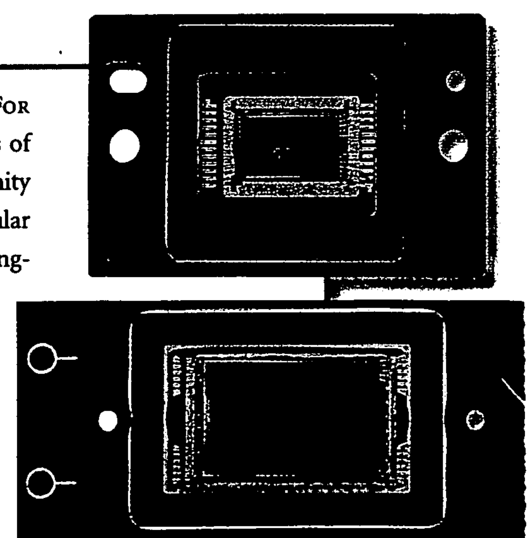
Take Spectra Like the Pros

IT'S NOT FOR EVERYONE, BUT IF YOU'RE SERIOUS ABOUT RECORDING RESEARCH-GRADE spectra of astronomical objects, the new **Self-Guided Spectrograph** from Santa Barbara Instrument Group (SBIG) should be on your list of things to check out. Coupled to any SBIG ST-7 or ST-8 camera, this slit-type, dual-grating spectrograph can capture spectra between 3800 and 7500 angstroms with resolutions of either 2.2 or 8 angstroms. Furthermore, the unit's sophisticated optical system takes advantage of the CCD camera's "guiding" chip and keeps a telescope locked on to the target during an exposure, just the way it does for conventional imaging. In the high-resolution mode, spectra of a 10th-magnitude star with a signal-to-noise ratio of 10:1 can be recorded with a 10-inch telescope and 20-minute exposure. Keep an eye out for our review early next year. Details of the $3,950 spectrograph are available at www.sbig.com or by contacting SBIG, 1482 East Valley Rd., Santa Barbara, CA 93150; phone: 805-969-1851.

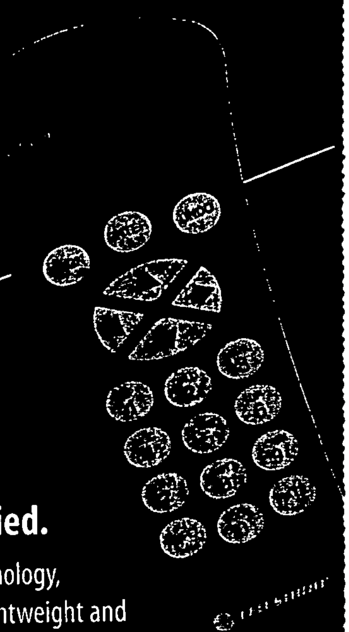
E as in Kodak



THE NAME KODAK IS WELL REGARDED IN THE WORLD OF ASTRONOMICAL IMAGING. FOR most of this century it was Kodak emulsions that recorded the comings and goings of the night sky. Kodak was there when digital imaging took off in the amateur community during the past decade. The company's CCD detectors are at the heart of many popular astronomical cameras. The big stir this year came with Kodak's introduction of its long-awaited **"E" version** of the KAF-0400 and KAF-1600 detectors. While these chips have increased sensitivity across most of the visual spectrum, they have particularly enhanced (thus the E nomenclature) sensitivity in the blue, where their predecessors were nearly blind. This is especially welcome by those doing tricolor imaging and photometry. The first manufacturer to offer cameras with E chips was Santa Barbara Instrument Group (reviewed last August, page 64), but others quickly followed suit, including Apogee, Finger Lakes Instruments, and Meade.

'99- OCT, NOV 2000 JAN, MAY, JUNE

What makes the new Celestron NexStar 5™ the most revolutionary computerized GOTO telescope on Earth?



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Aluminum Construction — All load bearing components (fork arm and drive base) are made of aluminum for rigid low vibration performance.

Optical Tube — Celestron's legendary 5" 1250mm f/10 Schmidt-Cassegrain optics is noted for its razor sharp image quality. The large 5" aperture allows you to clearly view deep space objects like galaxies, nebulae, clusters and double stars. An optional f/6.3 Reducer/Corrector provides a wider field and faster imaging.

The new Celestron NexStar 5 Schmidt-Cassegrain Telescope takes simplicity of use into a new dimension. A design and engineering tour d'force, the NexStar 5 combines a unique sculptured fork arm and drive base, state-of-the-future electronics, advanced mechanical engineering, and Celestron's renowned optics. Add to that an array of operation, convenience and software features that are optional or unavailable on most other GOTO telescopes. The result is nothing less than the perfect telescope for the first-time buyer who wants to start touring the Universe with virtually no learning curve or complicated set-up, or the serious amateur looking for advanced features not found on other GOTO telescopes.

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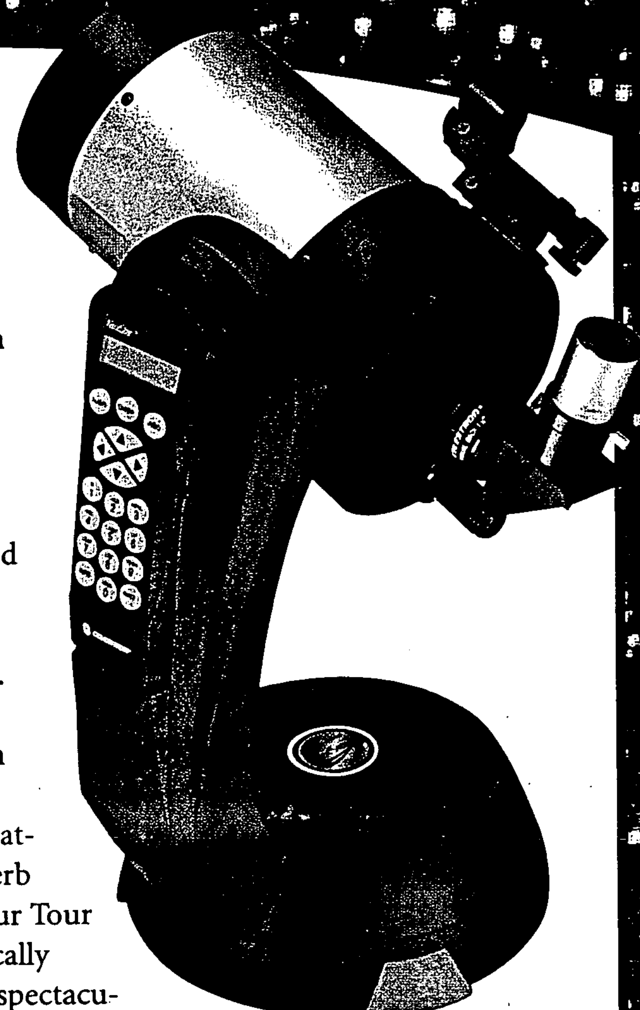

The joy of stargazing comes from observing the wonders of the heavens, not calculating alignments and positioning. The revolutionary new Celestron NexStar 5 does all that for you and more. Simply and easily.

NexStar 5 is light years ahead of other computerized GOTO telescopes, with Auto Align to get you up and observing immediately and an enormous object data base that includes more than 18,000 celestial sights.

Our Star Pointer Finderscope lets you quickly find any object in the sky, while variable slew speeds provide easy tracking for observation and astrophotography. You can attach our Hand Controller to the telescope's unique fork arm, or hold it for remote operation.

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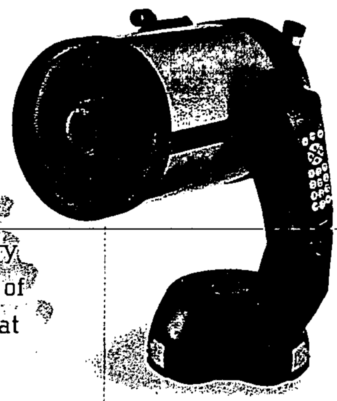
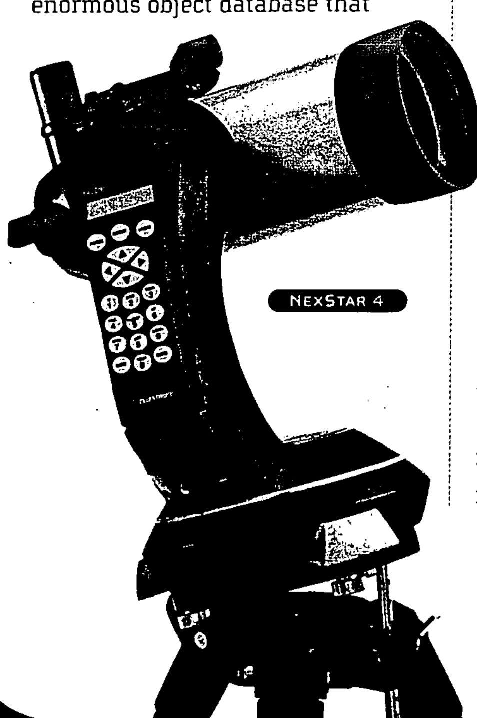


NEXSTAR 8

The joy of stargazing comes from observing the wonders of the heavens, not calculating alignments and positioning. The revolutionary new Celestron® NexStar™ line of telescopes does all that for you and more: Simply and easily. NexStar™ telescopes are light years ahead of other computerized "Go-To" telescopes. The **Auto Align** feature gets you up and observing immediately with an enormous object database that includes up to 18,000 celestial sights. Peer through the **StarPointer™** finderscope and quickly find any object in the sky, while variable slew speeds provide easy tracking for observation and astrophotography. There's even a communication port so you can control the NexStar™ from your personal computer.



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The newest member of the NexStar line, the NexStar 4, features high-quality **Maksutov-Cassegrain** optics and an optional tripod-wedge making it the most ideal telescope for astrophotography in its class.

The advanced NexStar 5 and NexStar 8 models feature the legendary **Schmidt-Cassegrain optical system** plus **Starbright™ multi-coatings** for superior resolution and optical clarity.

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NexStar telescopes are designed to go with you anywhere and perform beautifully. Using the same optical tube selected for the Space Shuttle, each NexStar gives you unsurpassed performance.

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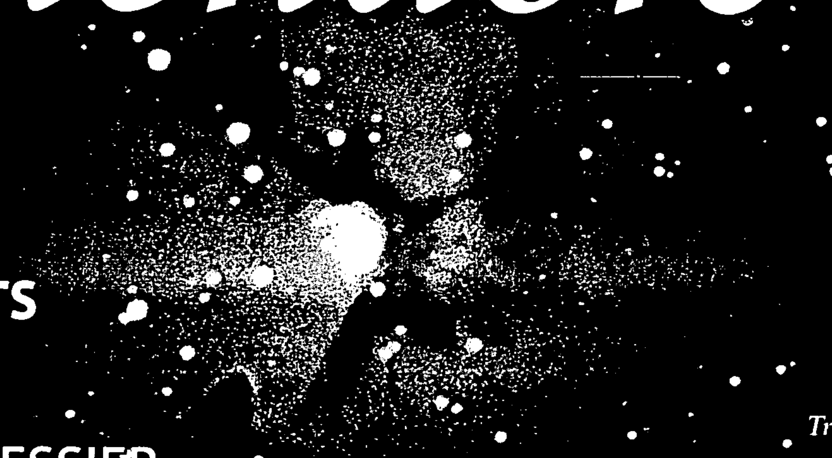

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